Introduction of Modeling Tools and Initial Applications

South Florida Water Management District
December 14, 2015

What's Happening Today

Today's Goal:

Continue to get on the same page…

Through information sharing and discussion at today's meeting,

- Improve our common understanding of the hydrology and how to organize our thoughts (morning)
- Brainstorm collectively to identified the group's preferences for a range of options to investigate further (afternoon)

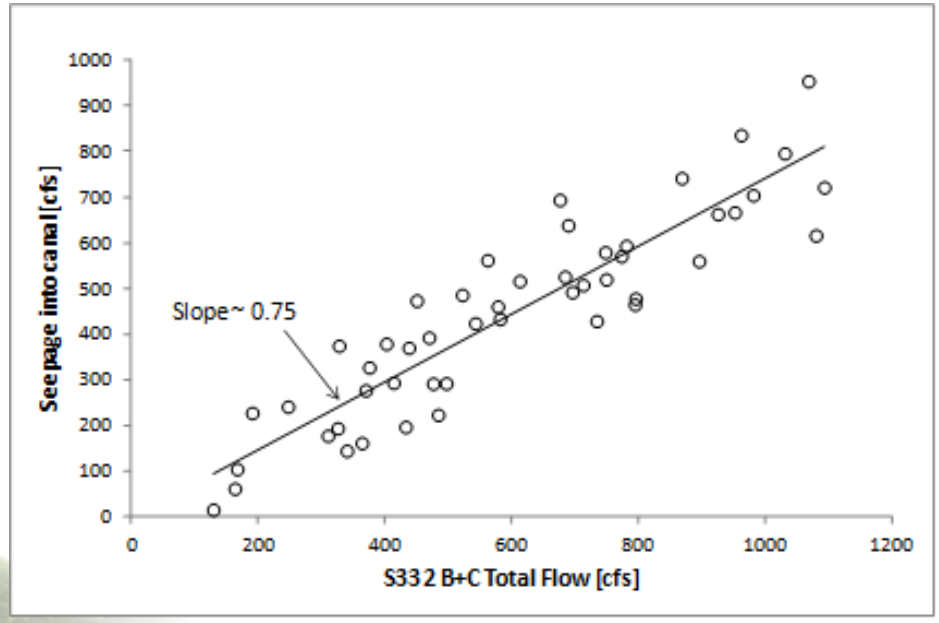
With this feedback, we will perform analysis and provide additional information at the next South Dade Investigations workshop on February 2.

Presentation Topics

- Introduction to Modeling Tools
  - Learning from Historical Data
  - Regional Simulation Model (RSMGL)
  - Supporting tools
- Demonstration on Use of Tools
  - Review a range of possible conditions
- Review Summary Findings
  - Promote common understanding
  - Inform this Afternoon's Brainstorm Discussion

Model are Informed by History

- Historical data analysis is a key element of model refinement. As part of the South Dade Investigations effort, several efforts to examine historical data have resulted in improvements to model assumptions and parameters.



Modeling Tools

- Primary Modeling Tool
  - Integrated Ground Water and Surface Water Model : Regional Simulation Model (RSM)
- Supporting Modeling Tool
  - Seepage Analysis Tool: GFLOW
  - Groundwater Modeling Tool: MODFLOW

Primary Modeling Tool: Regional Simulation Model (RSM)

- Developed by the South Florida Water Management District
- Used as a regional and sub-regional scale hydrologic model
- Developed with South Florida's unique hydrology in mind
- Simulates canal, overland & groundwater flows
- Simulates all major water budget components
- Has features to handle local scale hydrology
- Has capability to handle water management operations

Primary Model: RSM-GL

- An Implementation of the RSM specific to the Everglades and Lower East Coast Service Areas.
- Previously applied for the CERP DECOMP and the Central Everglades Planning (CEPP) projects
- Currently, it is being updated to support ModWaters and C-111 South Dade projects
- A regional scale model and should be used for planning purposes
- Able to capture current or proposed changes in southern system infrastructure and operations.

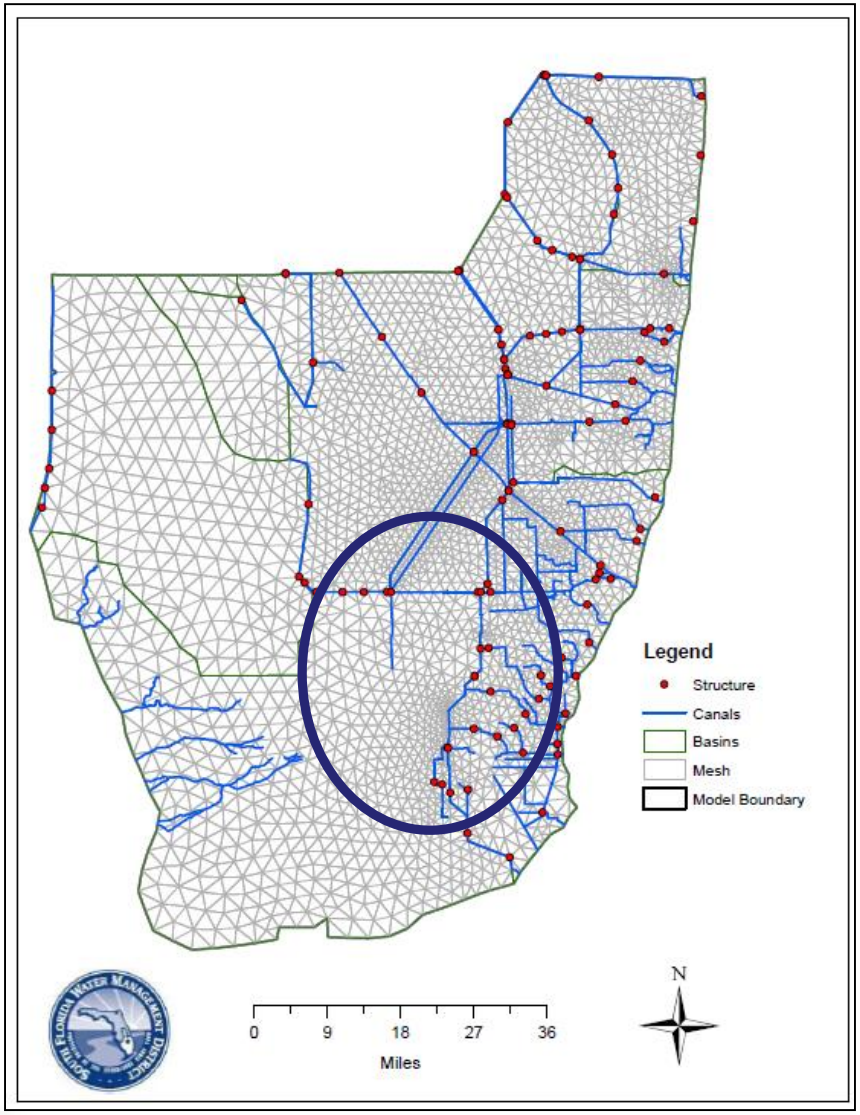
RSM-GL Details

Model Domain:
Everglades and Lower East Coast service areas
Domain size: 5,825 sq. miles

Mesh Information:
Finite element mesh
Number of cells: 5,794
Average size: ~ 1 sq. mile

Canal Information:
Total length: ~ 1,000 miles
Number of segments: ~ 1,000
Average length: ~ 1 mile

Run Time:
~ 1 day

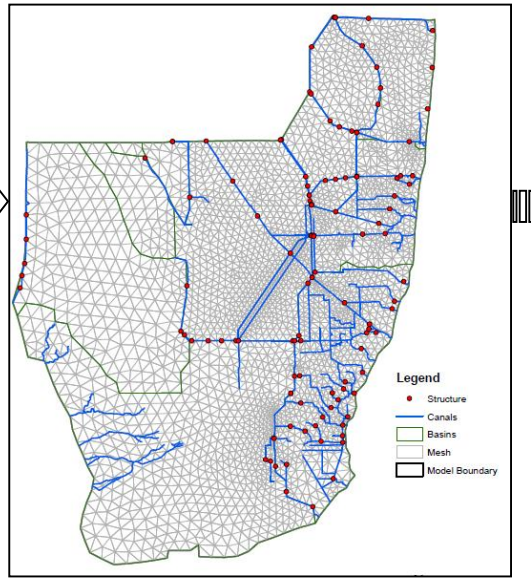


Modeling Approach using RSM-GL

Scenario

Model Input

- **Climatic Input**
  - – Rainfall
  - – ET
- **Boundary Conditions**
- **Project Features**
- **Land Use/Land Cover**
- **Water Demands**
- **Operating Criteria**



Model Output

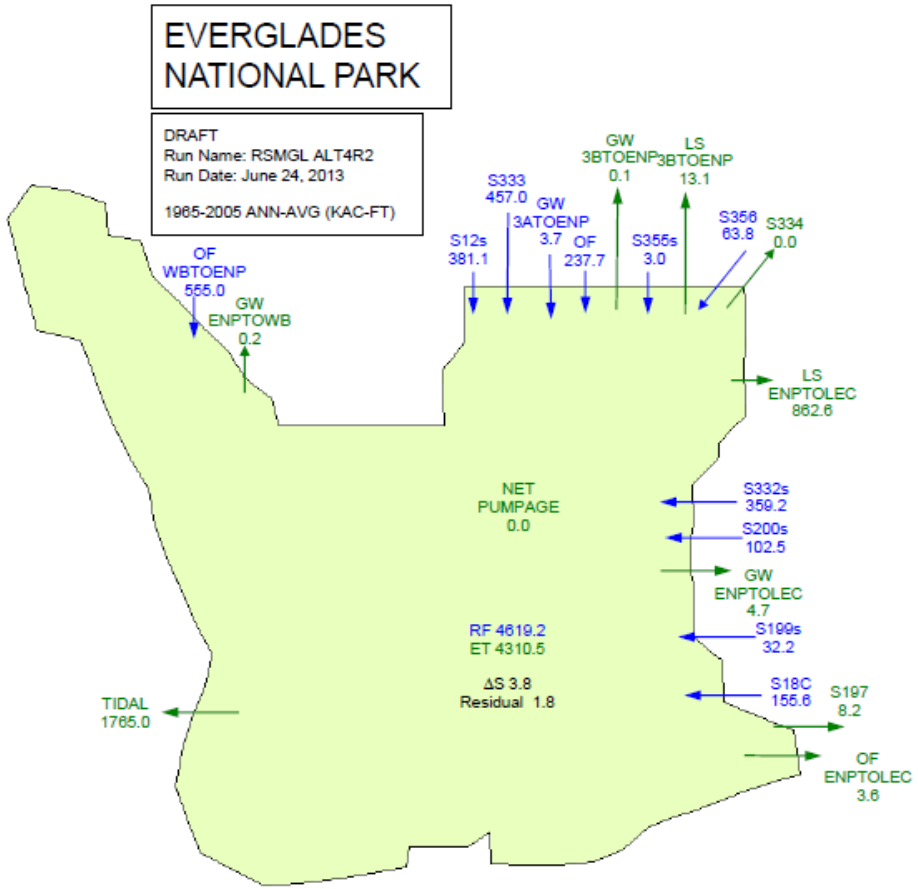
- Daily time series of water levels, flows
- Demands not met

Evaluation
(Environmental, Flood Control, Water Supply, etc…)

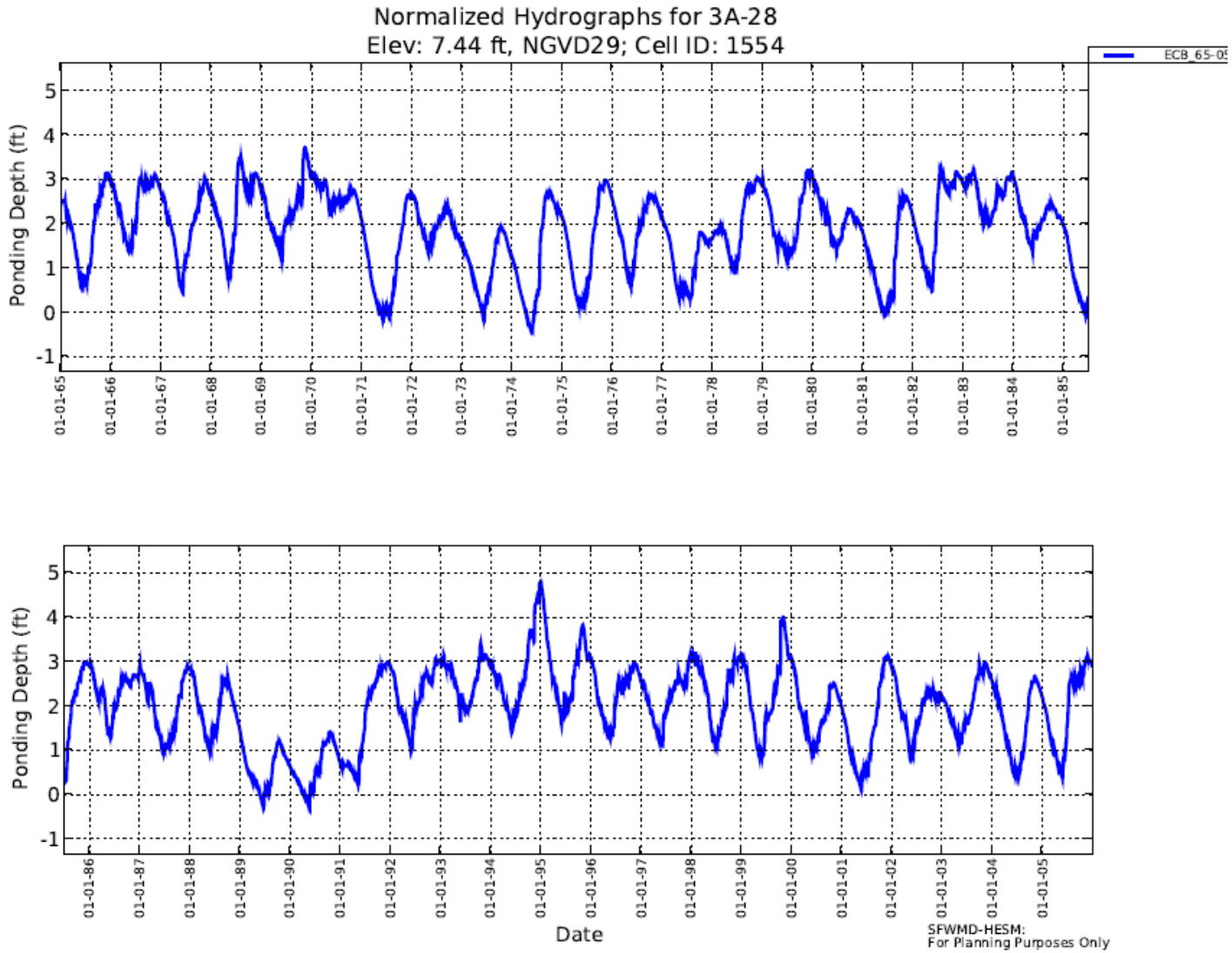
Climatic Simulation Period of record:
1965-2005

RSM-GL Modeling Products

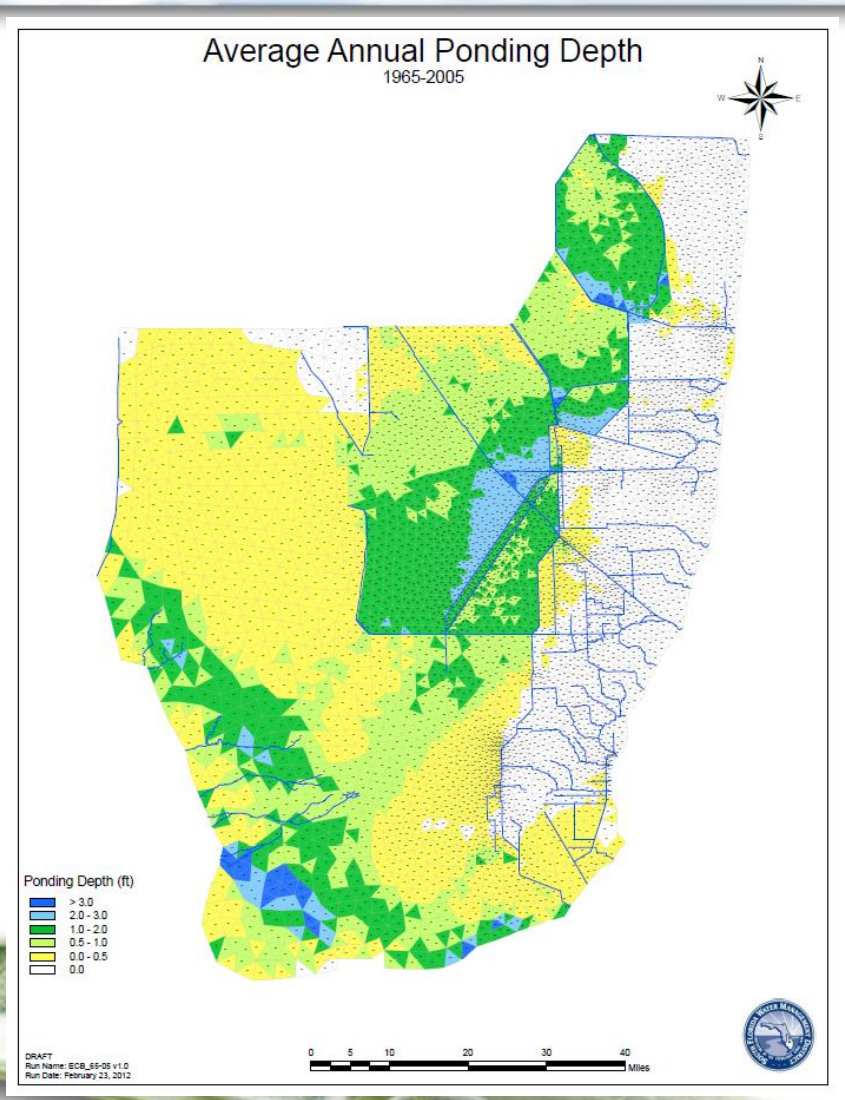
- Stage and Flow Hydrographs
- Stage and Flow Duration Curves
- Ponding Depths Maps
- Stage Maps
- Hydroperiod Maps
- Groundwater Flow Vector Maps
- Overland Flow Vector Maps
- Transect Flows
- Basin Water Budgets

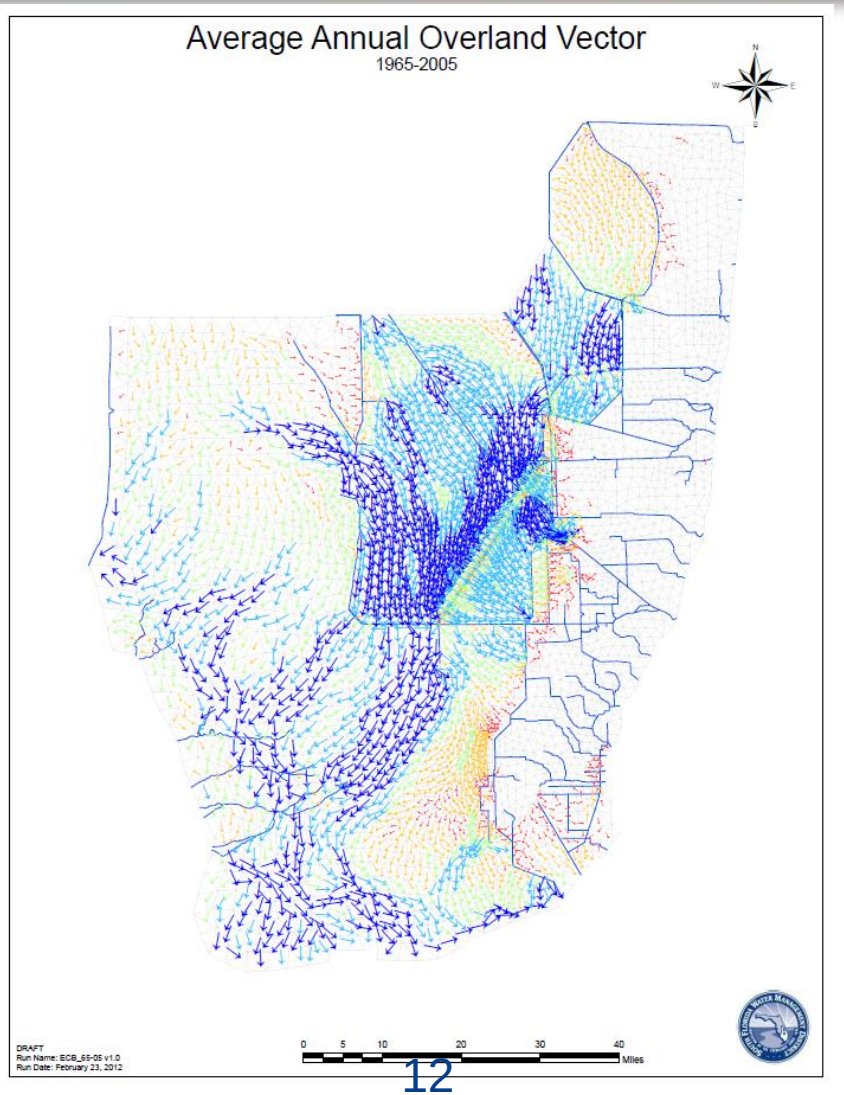


RSM-GL Example Hydrographs

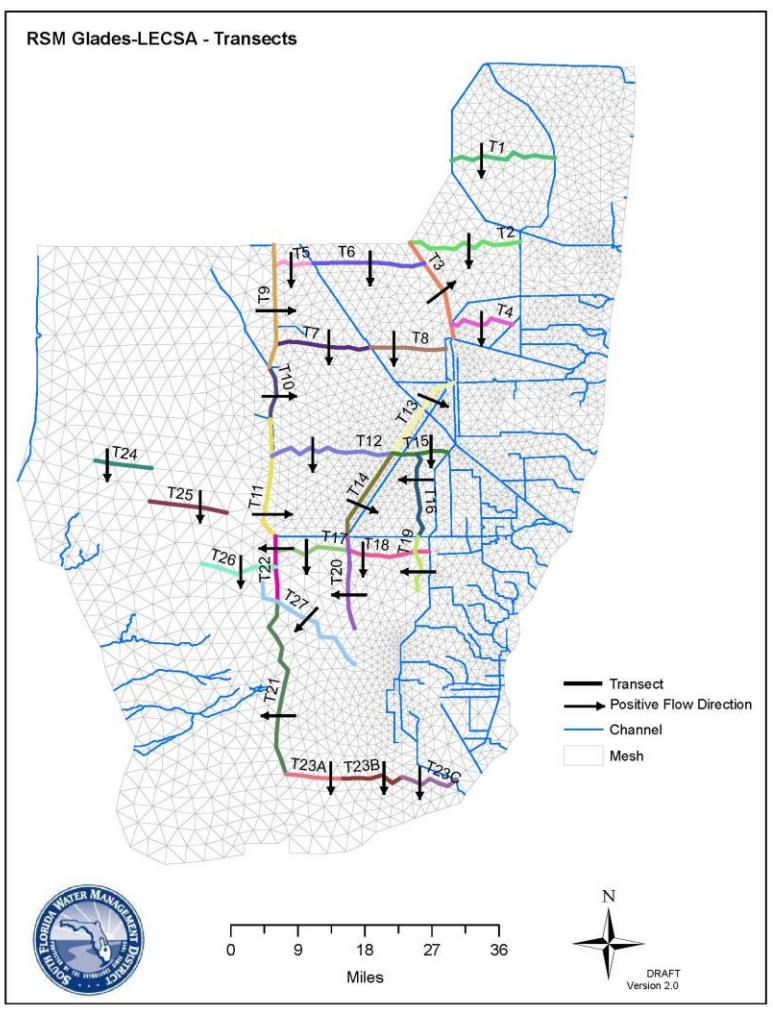


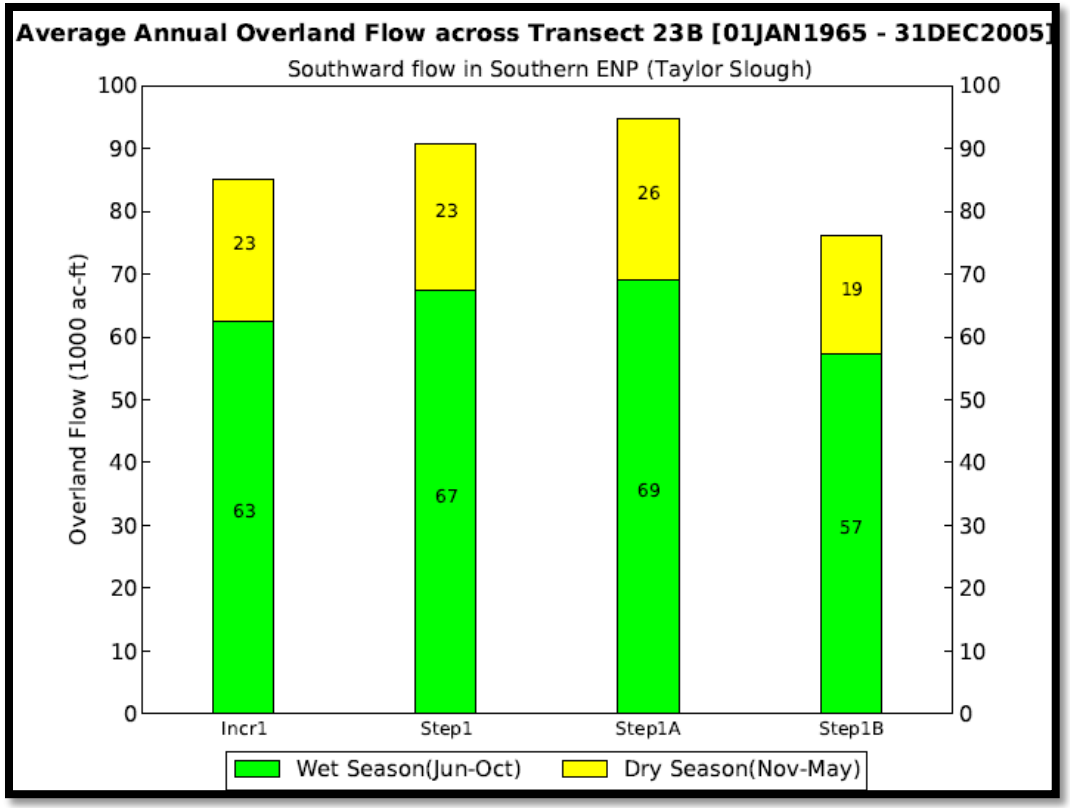
RSM-GL Example Maps





RSM-GL Example Flow Transects

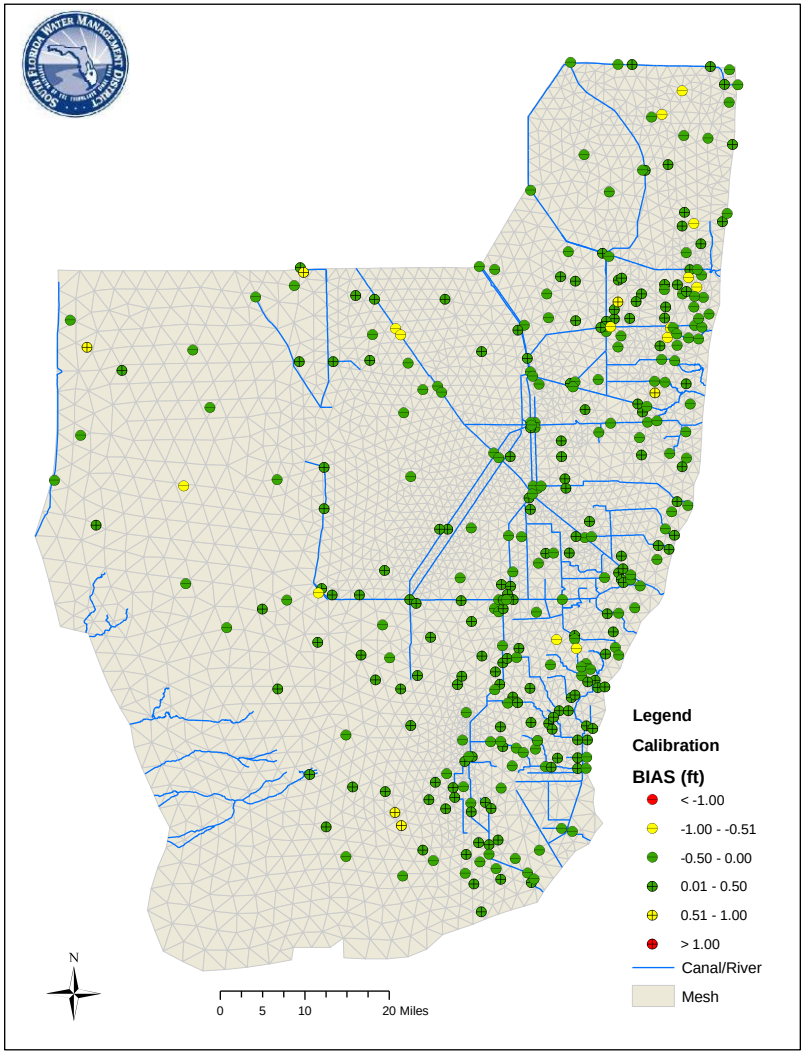


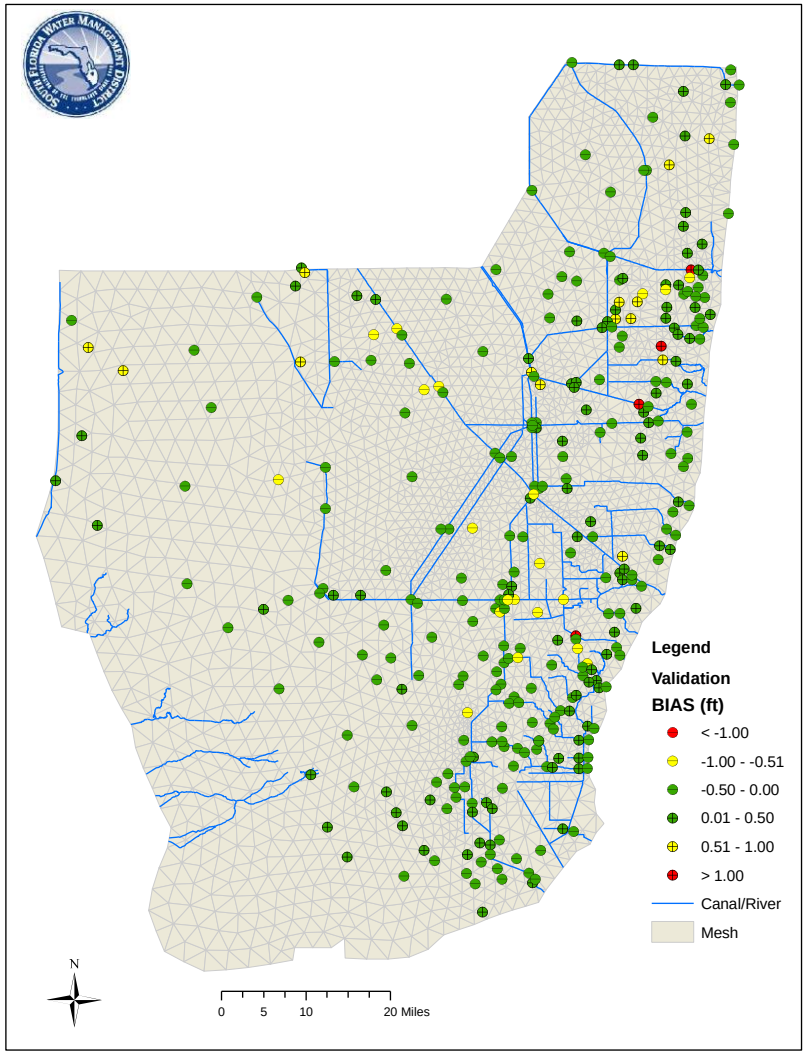


Model Calibration

- The model was calibrated to match historical data dating from 1/1/84 to 12/31/95. The model was independently validated to match data from 1/1/81 to 12/31/83 and from 1/1/96 to 12/31/2000.
- Historical time-series data from 336 gages were used for the calibration.
- Objective was to minimize the weighted sum of squares of the absolute bias and RMSE calculated at each measuring site.
- Calibration provided model values including:
  - Aquifer saturated hydraulic conductivity values
  - Seepage coefficients & canal leakance values
  - Overland and canal roughness coefficients
  - Evapotranspiration coefficients

RSM-GL Bias (Calibration vs. Validation)

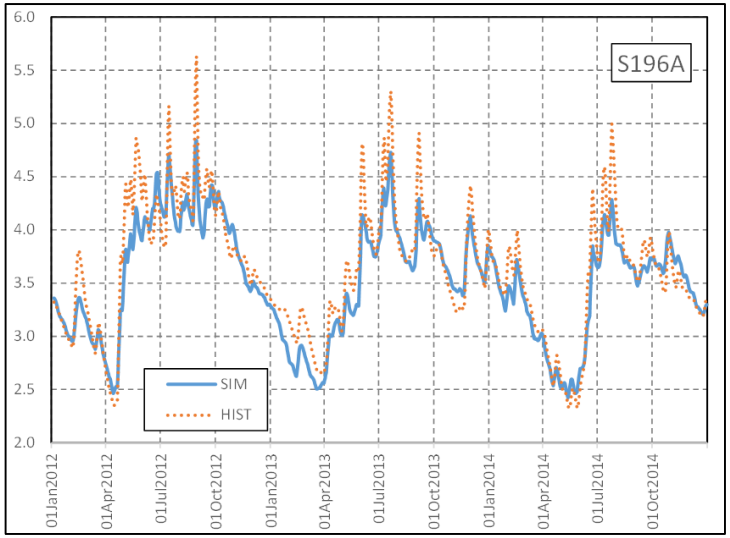


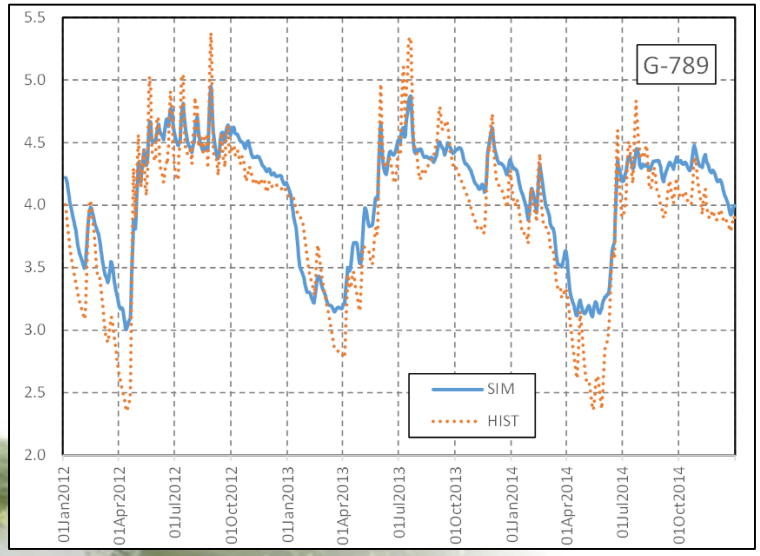


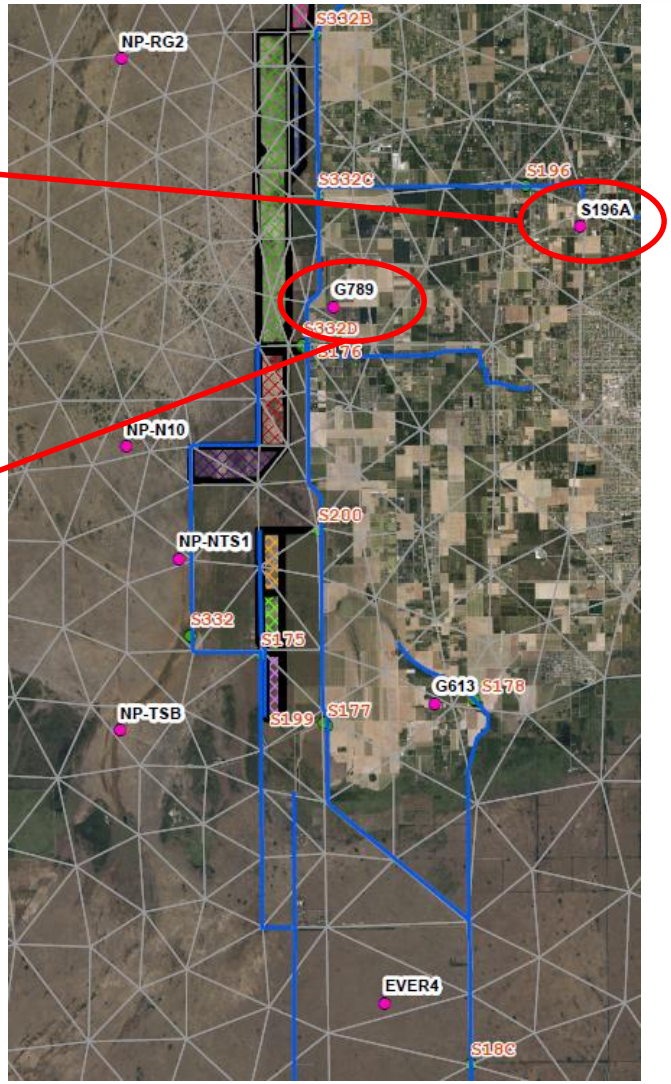
For Added Confidence…

- As an additional validation step, a quick check was made of the model performance using recent rainfall and S331 flows (2012-2014).
- This step helps to ensure that the model is robust in representing a variety of conditions (including recent experiences), even if they were not in the calibration effort.

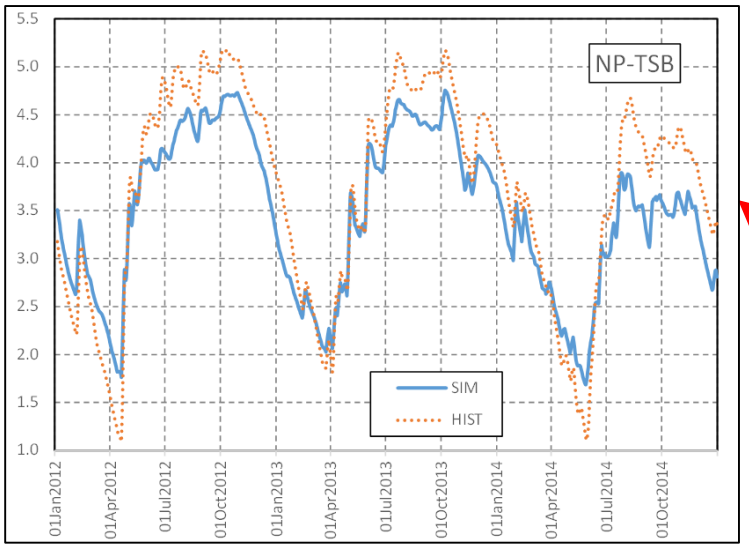
Example Performance

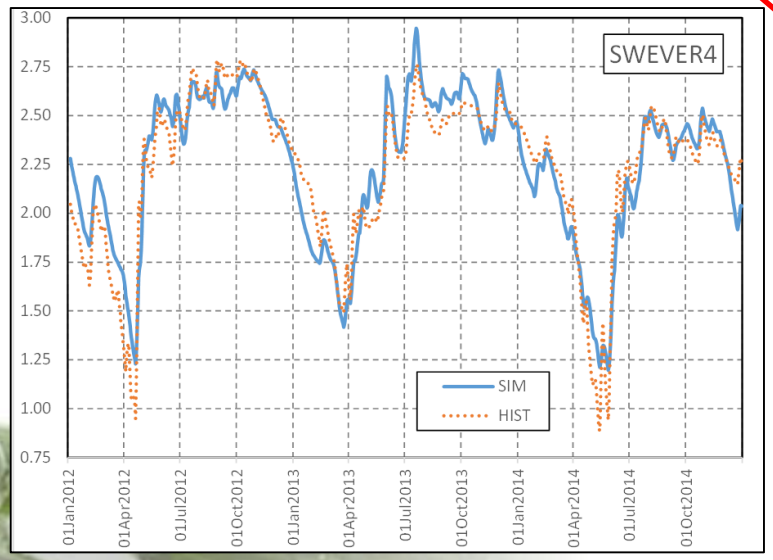


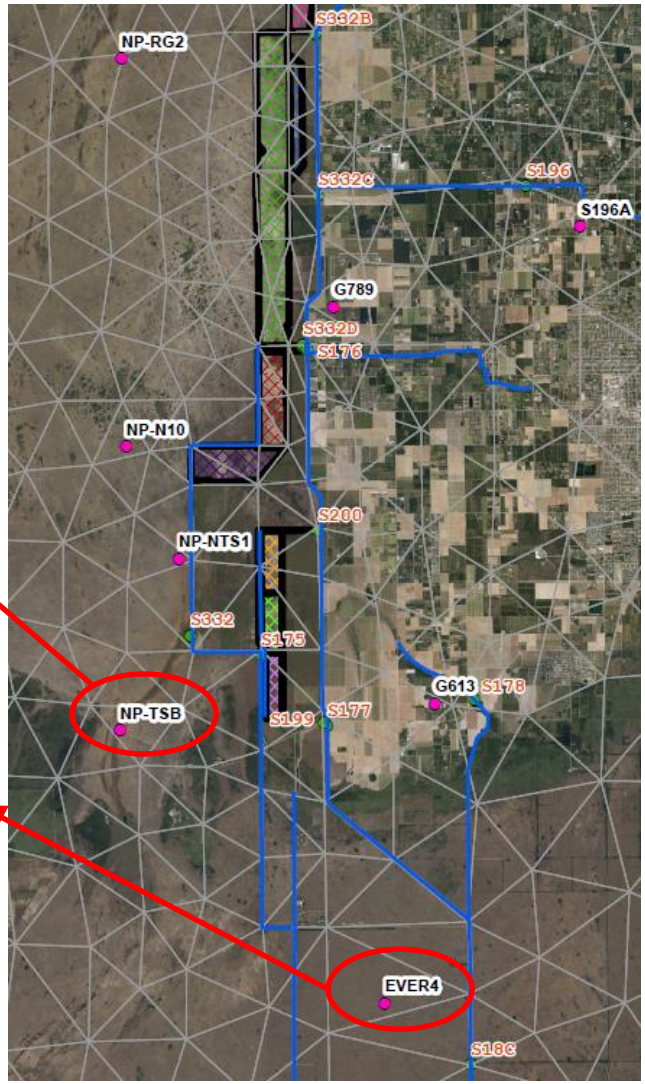




Example Performance (Continued)



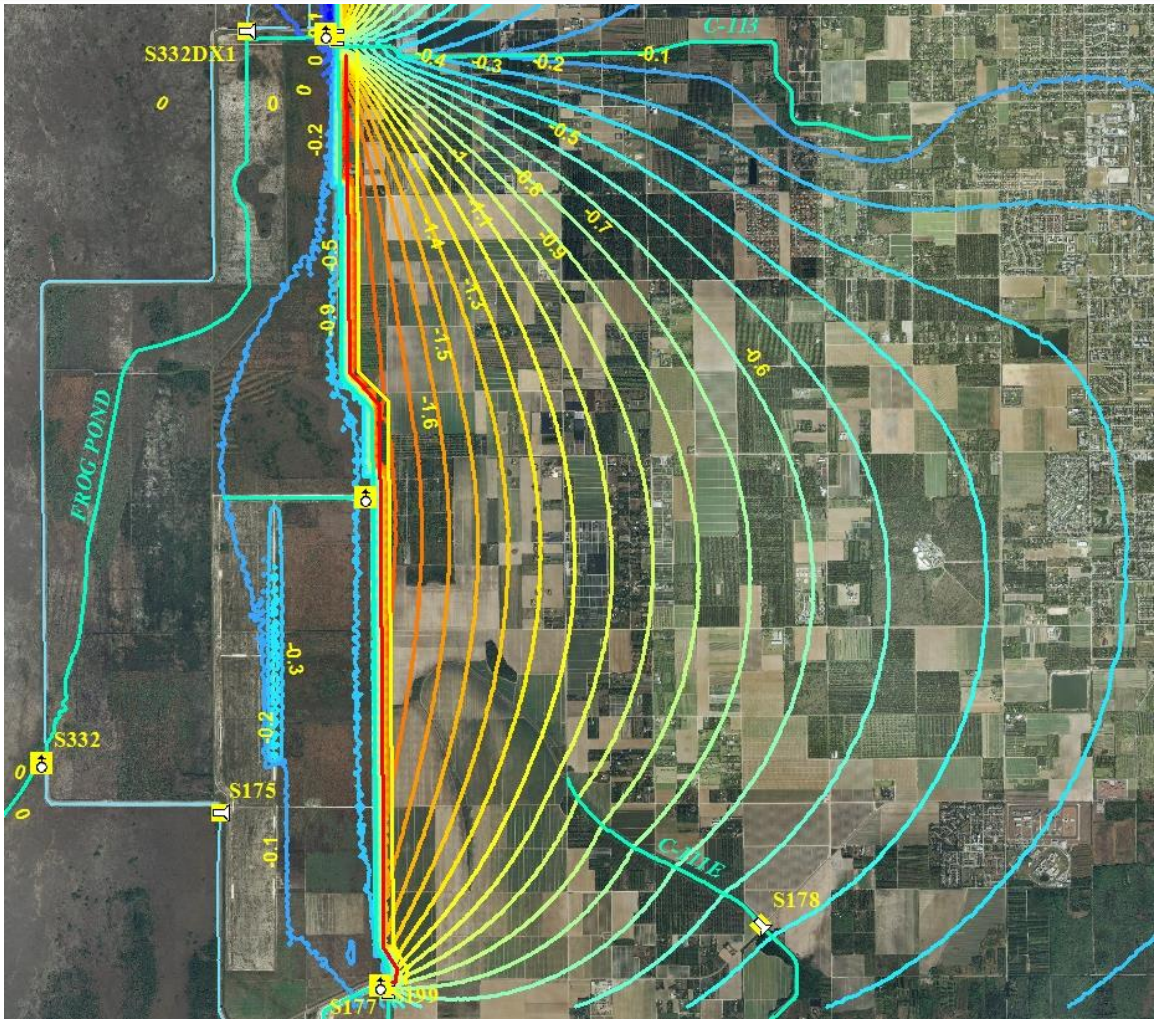




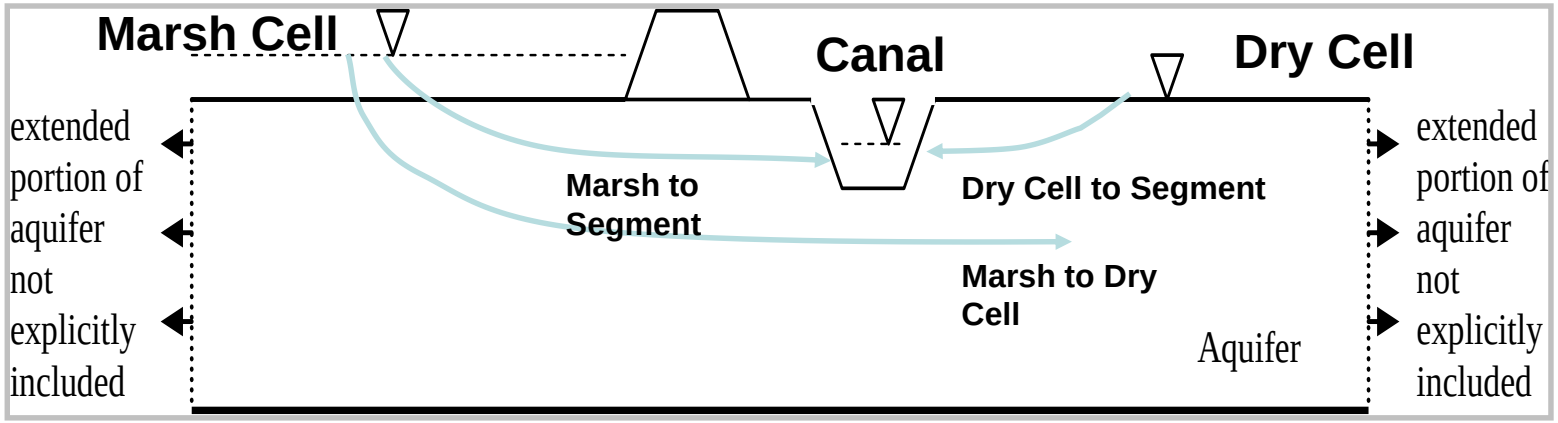
GFLOW: Seepage Analysis Tools

GFLOW : A stepwise groundwater flow modeling system based on the analytic element method (AEM).

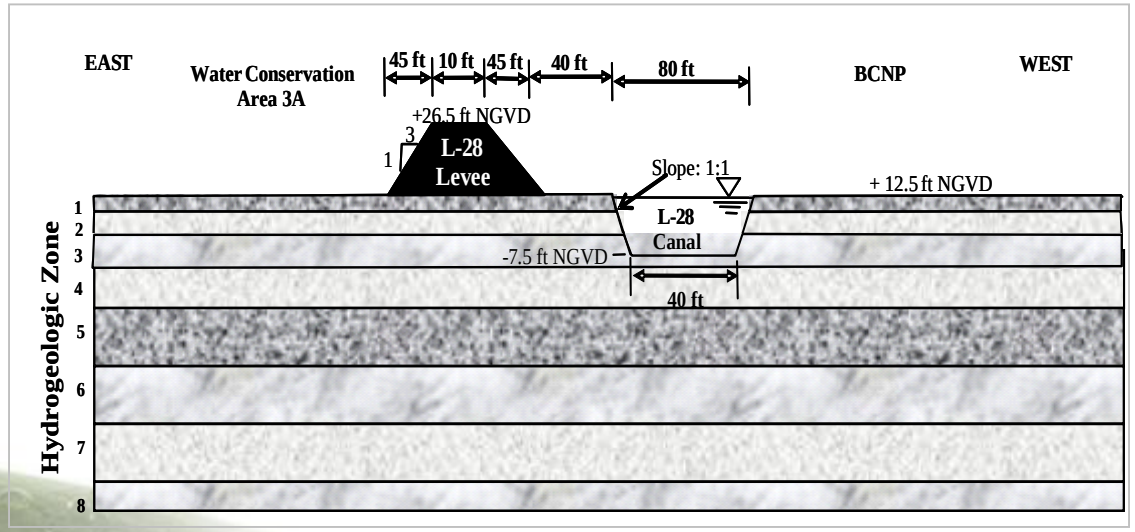
For Example: Groundwater changes with seepage barrier + lower canal level



GFLOW: Seepage Analysis Tools



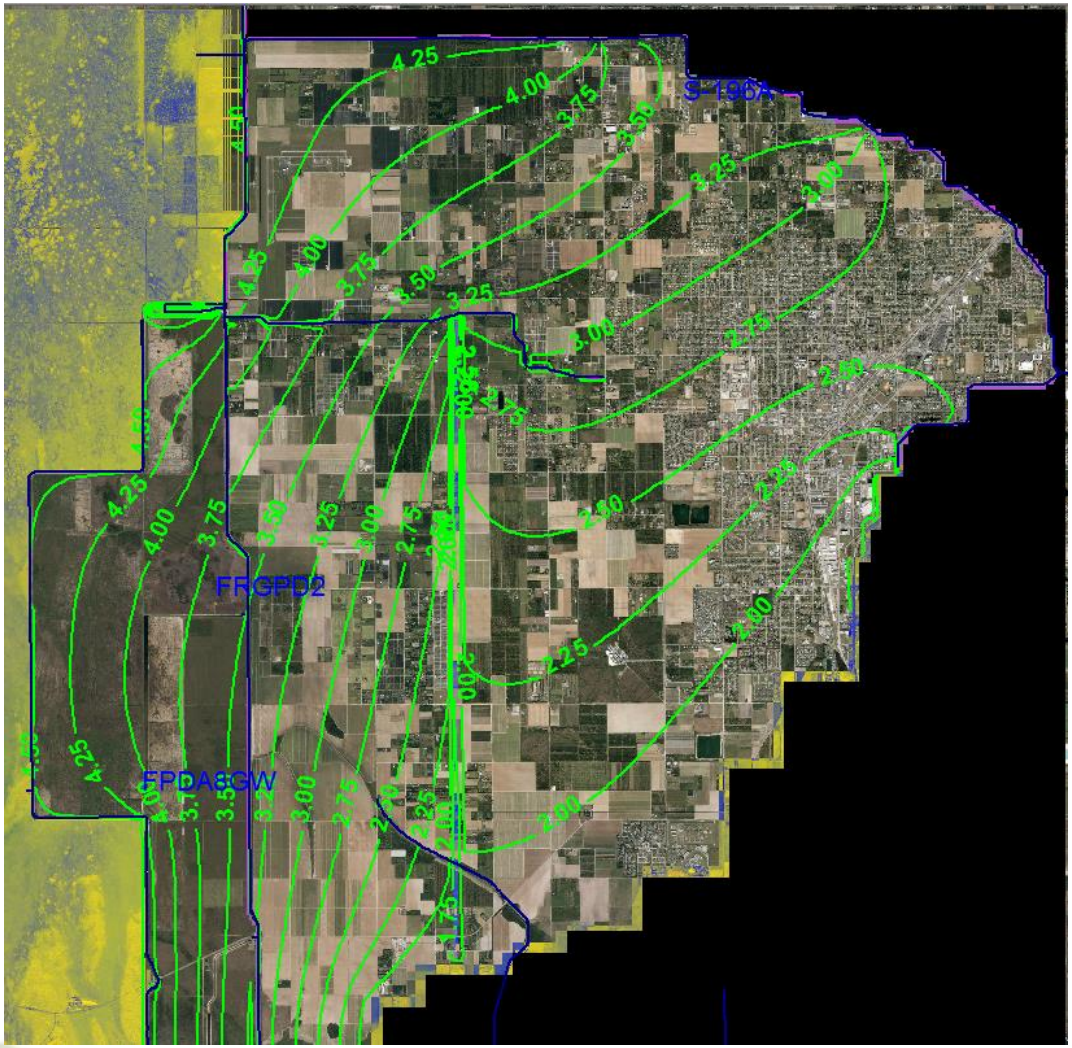
Used in South Dade Investigation to analyze Seepage and feed to RSM-GL



MODFLOW: Groundwater Modeling Tools

MODFLOW: a 3D finite-difference groundwater model developed by USGS

For Example: Groundwater levels with an assumed agricultural drainage canal



Additional Model Development (MDRSM)

- Effort is underway in collaboration with partner agencies to develop an operations based model for Miami Dade using RSM
- The main focus of the model is to evaluate current and future operational alternatives for flood control and water supply.

Model Domain:

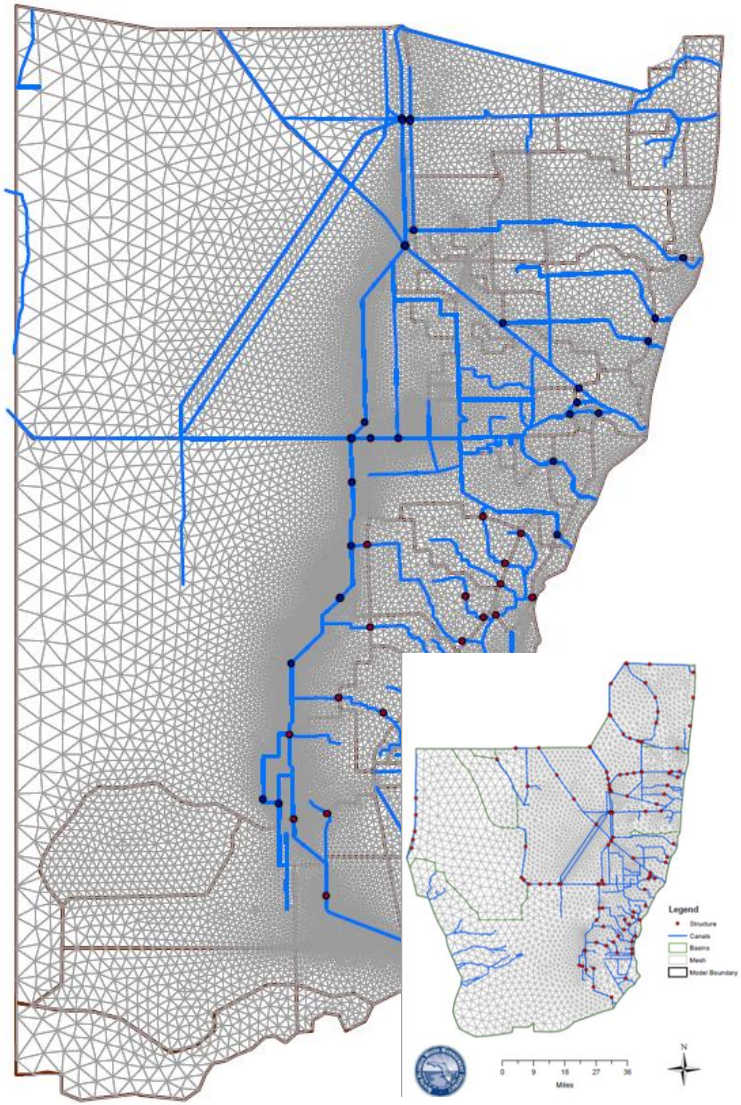
- Domain size: 2425 sq. miles
- A subset of RSMGL; I-75 and North New River on the north and along the WCA-3A western boundary on the west

Mesh Information:

- Number of cells: 28,990 cells
- Average size: ~ 0.08 sq. mile

Canal Information:

- Total length: 620 miles
- Average length: ~ 0.25 mile



DEMONSTRATION ON USE OF MODELING TOOLS

Modeling a Range of Conditions

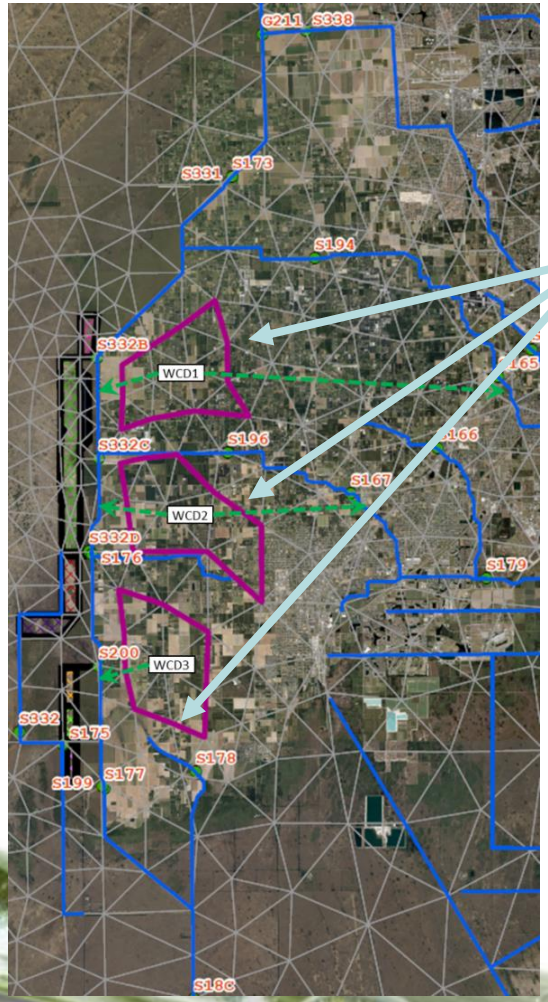
- The models allow us to look at a range of possible conditions, both expected and purely “what-if” scenarios.
- For example, the model can display:
  - Near-current conditions (e.g. ERTP or Increment 1)
  - Possible future conditions (e.g. ModWaters or C111 project features)
  - Everglades Restoration (e.g. CEPP)
- For these conditions (or others) we can then assess relative changes such as:
  - Operational changes
  - Infrastructure changes

Initial Modeling Outcomes

- Several “Proof of Concept” scenarios were run to examine the ability to move toward the goals identified in the South Dade Investigations discussion; for example:
  - Proof of Concept 1 (POC1) implemented local drainage districts with pumps toward Biscayne coastal structures and the L31N/C111 canals
  - Proof of Concept 2 (POC2) implemented lower canal operating levels in the L31N/C111 canals
  - Proof of Concept 3 (POC3) implemented lower canal operating levels in the L31N/C111 canals plus a seepage barrier
- Outcome: It is possible to improve toward identified objectives!
  - Improvements were frequently observed in the Everglades, Southern Estuaries and agricultural areas
  - Care must be taken to identify unintended adverse impacts

Initial Modeling Outcomes (continued)

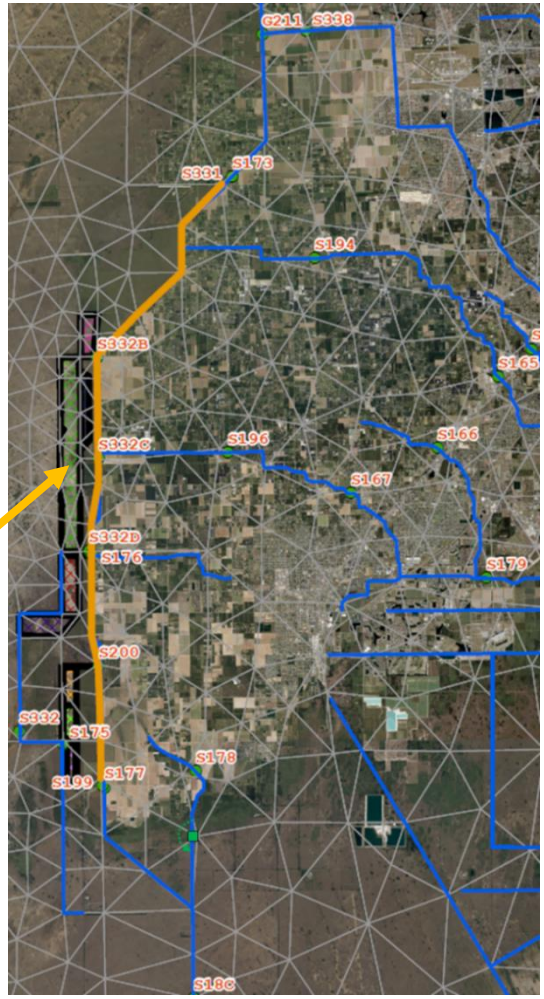
Proof of Concept 1 (POC1):



Simulated Local Drainage Districts

Simulated Seepage Barrier (approximately 40 ft deep)

Proof of Concept 3 (POC3):

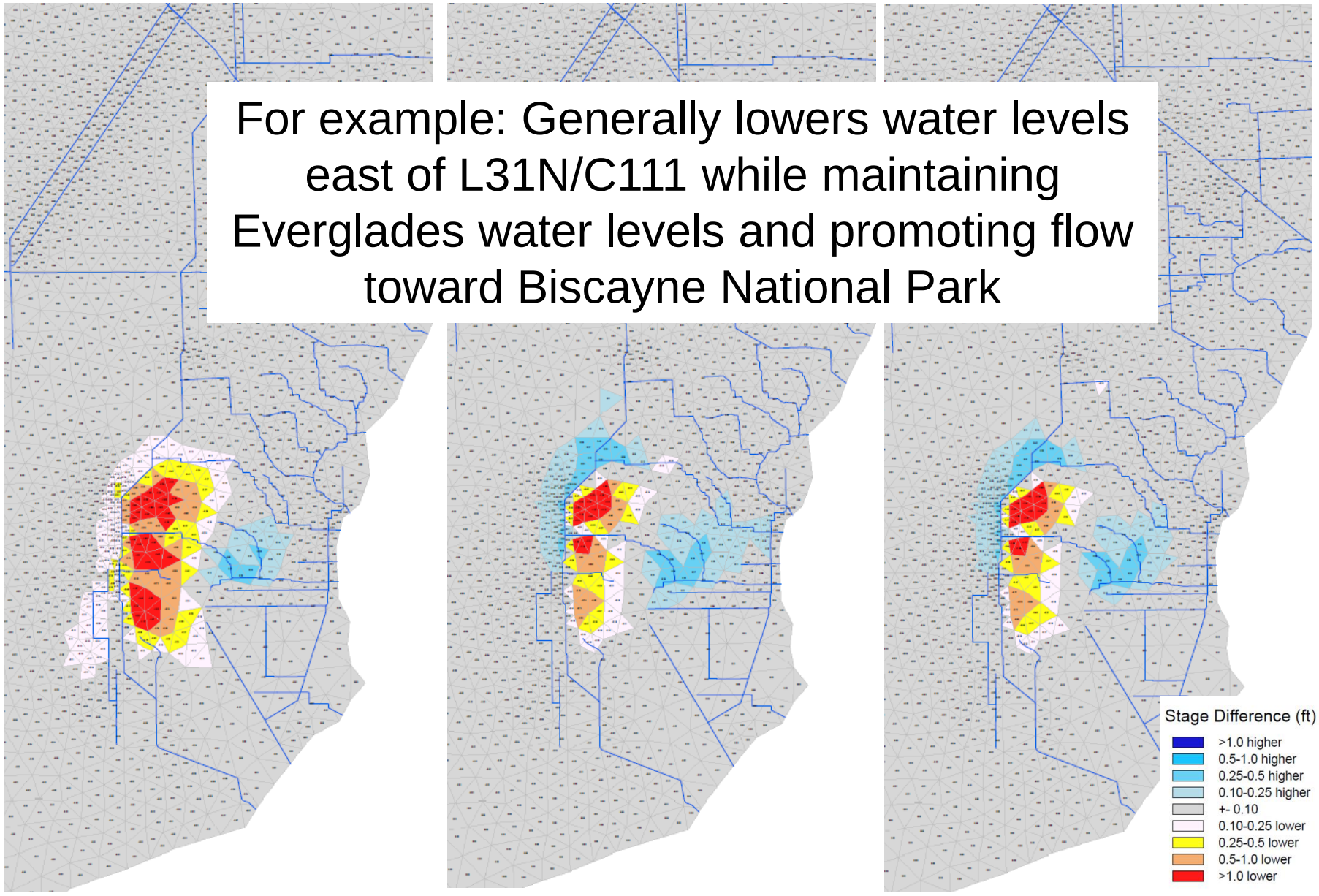


Wet: WY1970

Dry: WY1971

Average: WY1976

For example: Generally lowers water levels east of L31N/C111 while maintaining Everglades water levels and promoting flow toward Biscayne National Park



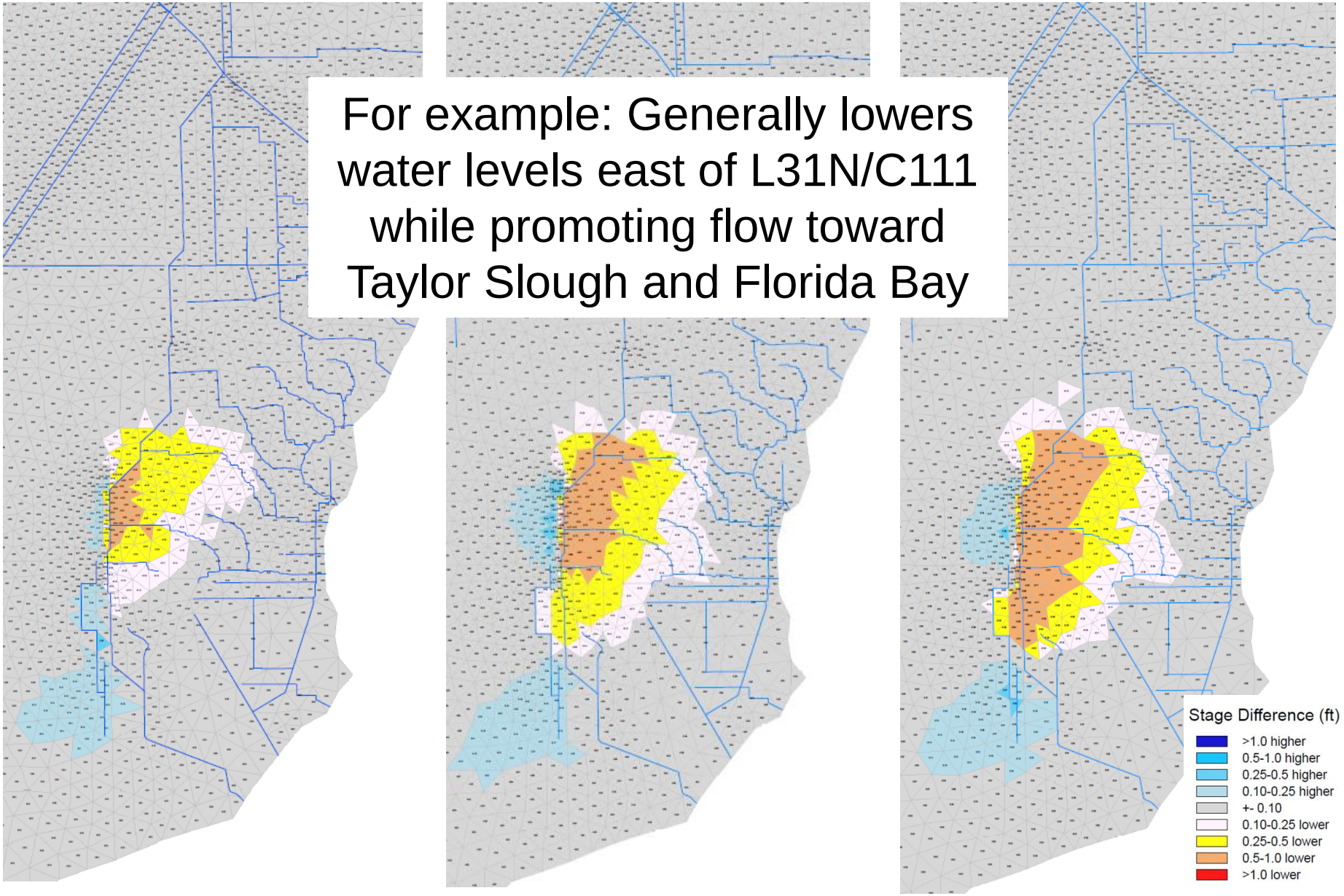
Regional Evaluation of POC1 : December Stage Difference Maps

Wet: WY1970

Dry: WY1971

Average: WY1976

For example: Generally lowers water levels east of L31N/C111 while promoting flow toward Taylor Slough and Florida Bay



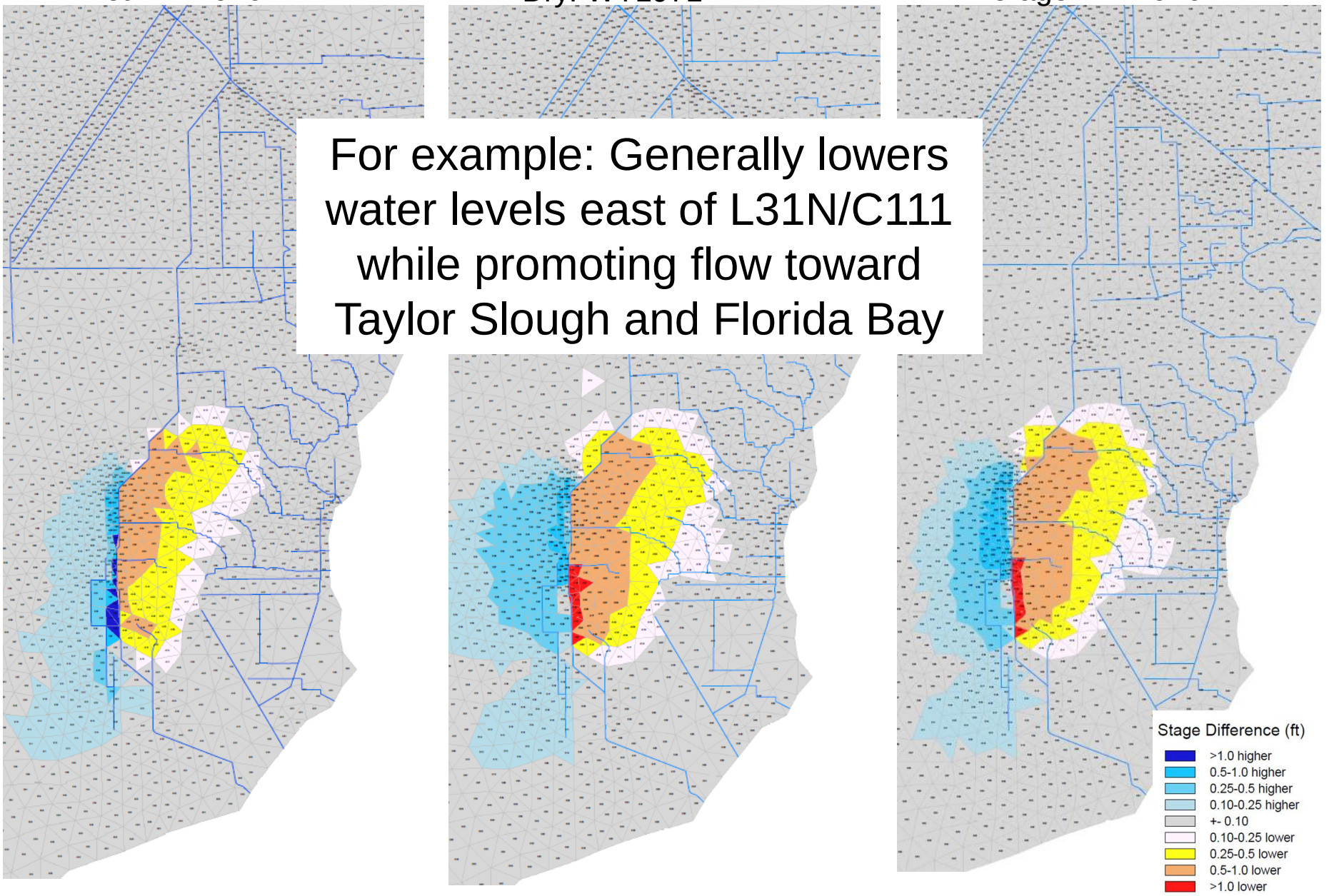
Regional Evaluation of POC2 : October Stage Difference Maps

Wet: WY1970

Dry: WY1971

Average: WY1976

For example: Generally lowers water levels east of L31N/C111 while promoting flow toward Taylor Slough and Florida Bay



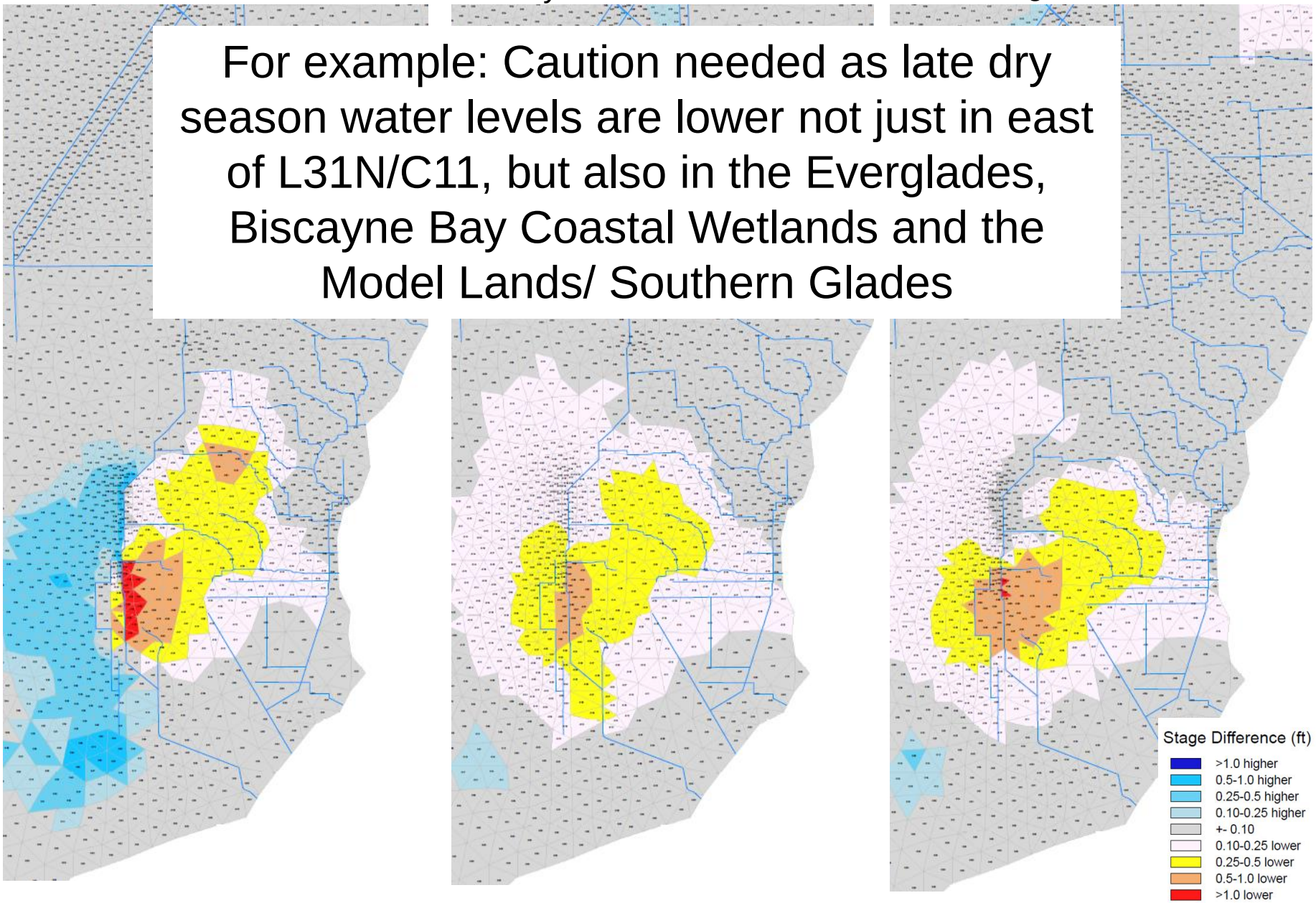
Regional Evaluation of POC3: October Stage Difference Maps

Wet: WY1970

Dry: WY1971

Average: WY1976

For example: Caution needed as late dry season water levels are lower not just in east of L31N/C11, but also in the Everglades, Biscayne Bay Coastal Wetlands and the Model Lands/ Southern Glades



Regional Evaluation of POC3 : April Stage Diff Maps

DRAFT

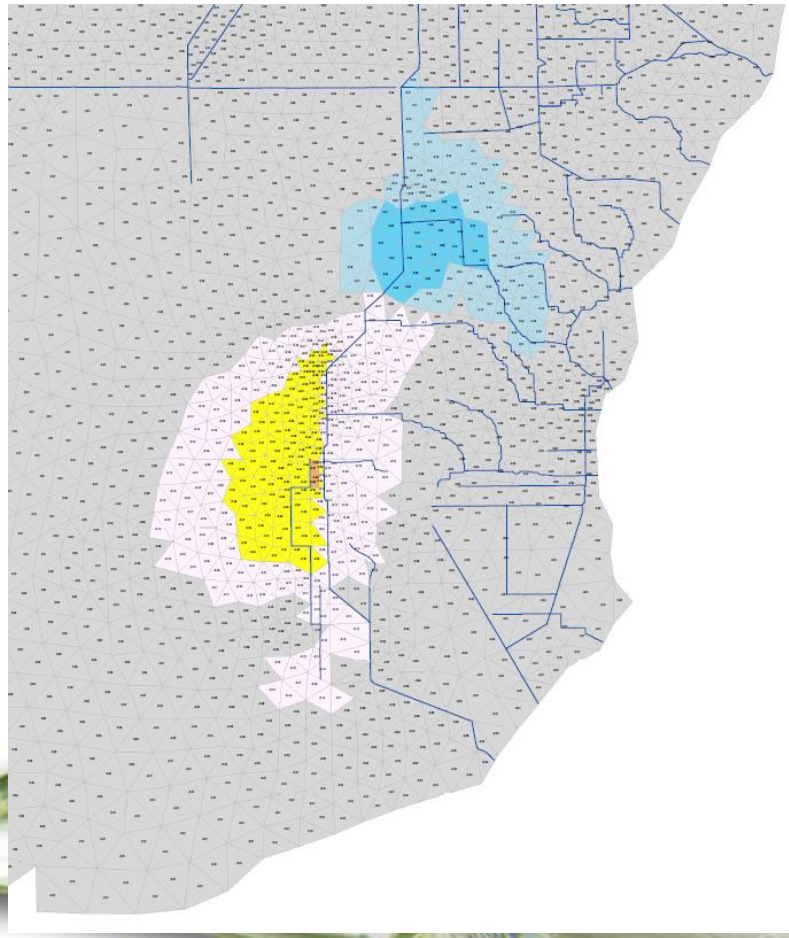
REVIEW OF SUMMARY FINDINGS

To Help Inform the Discussion:

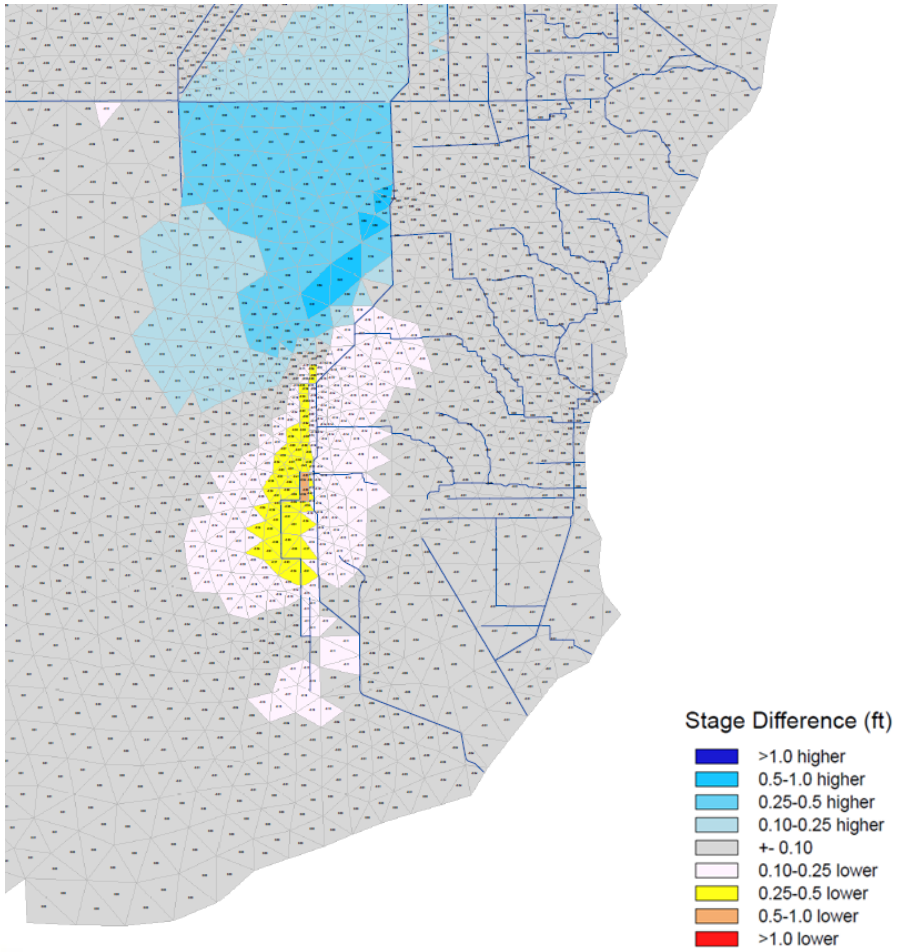
- We have heard many valuable suggestions and feedback from the group – THANK YOU!
  - Some ideas proposed include suggested operational changes, addition/improvement of structures, addition of secondary canals, addition of seepage barriers, use of ASR, etc…
- The following slides summarize investigations into several key features of the existing South Dade area or the potential for various proposed features to influence this area to help promote common understanding.

Stage Difference Maps for December Example Examining S331 Use

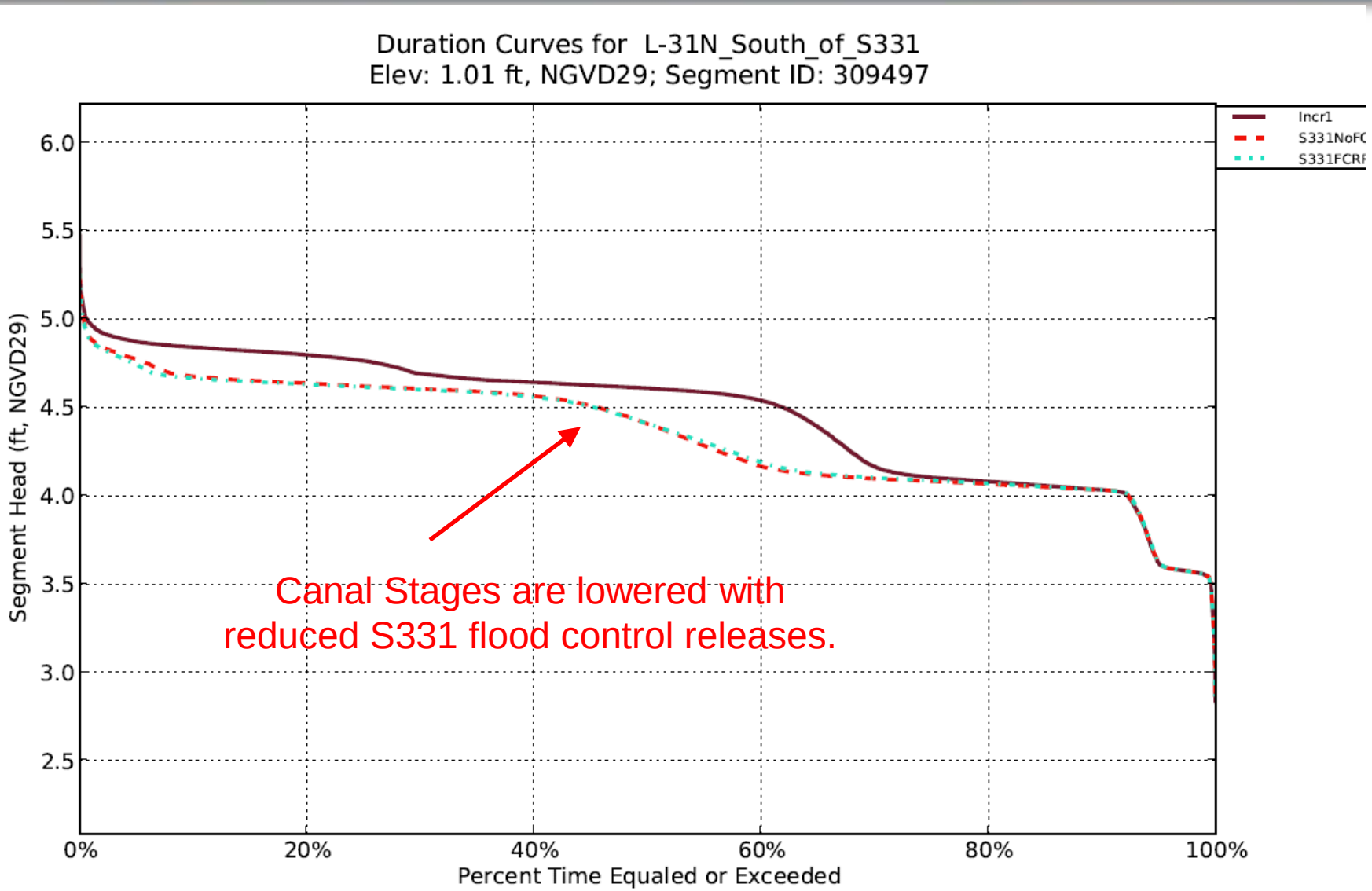
Example without S331 Flood Control Releases



Example without S331 Flood Control and with Increased L29 Stages

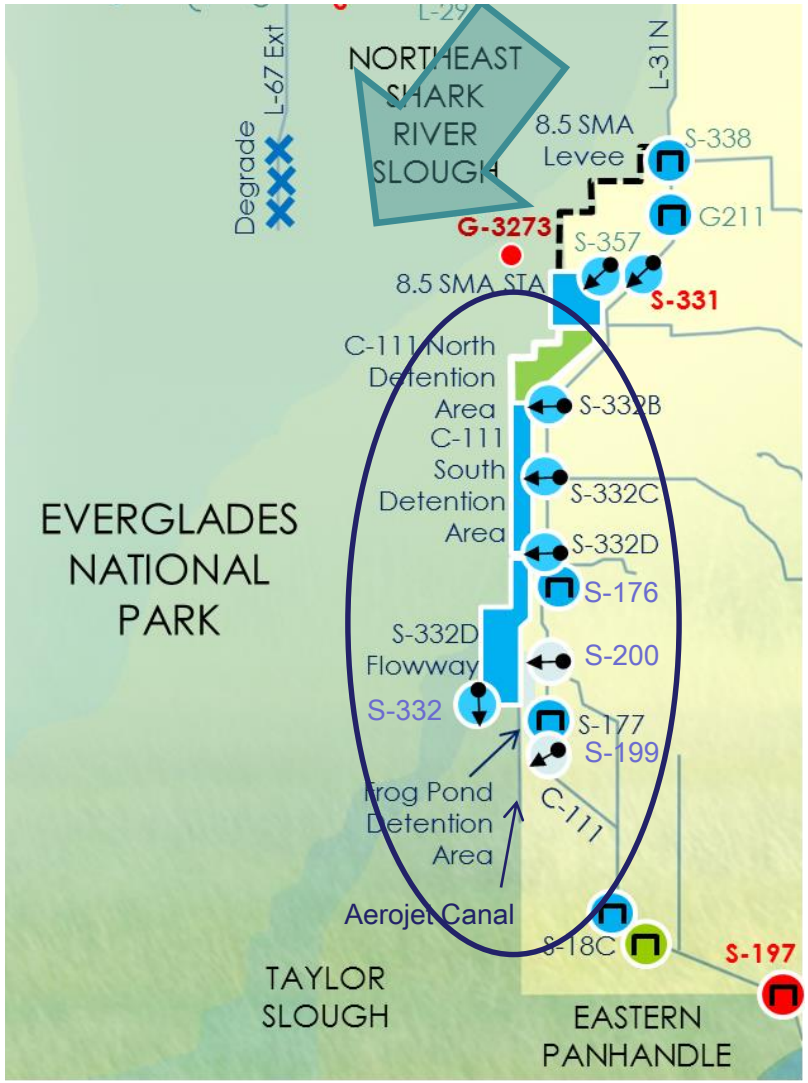


Example Examining S331 Use: Canal Duration Curves (South of S331)



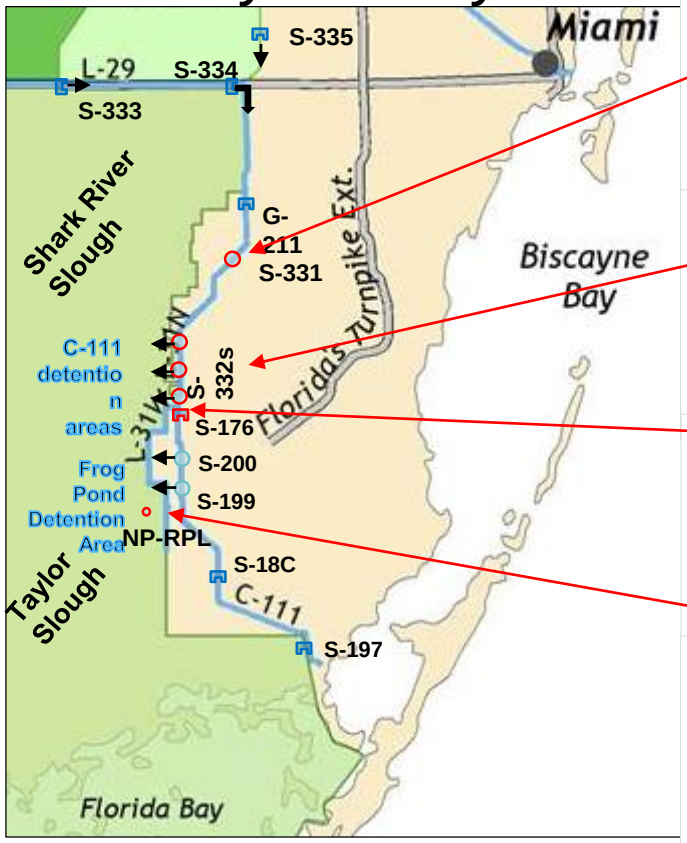
How do Detention Areas Function?

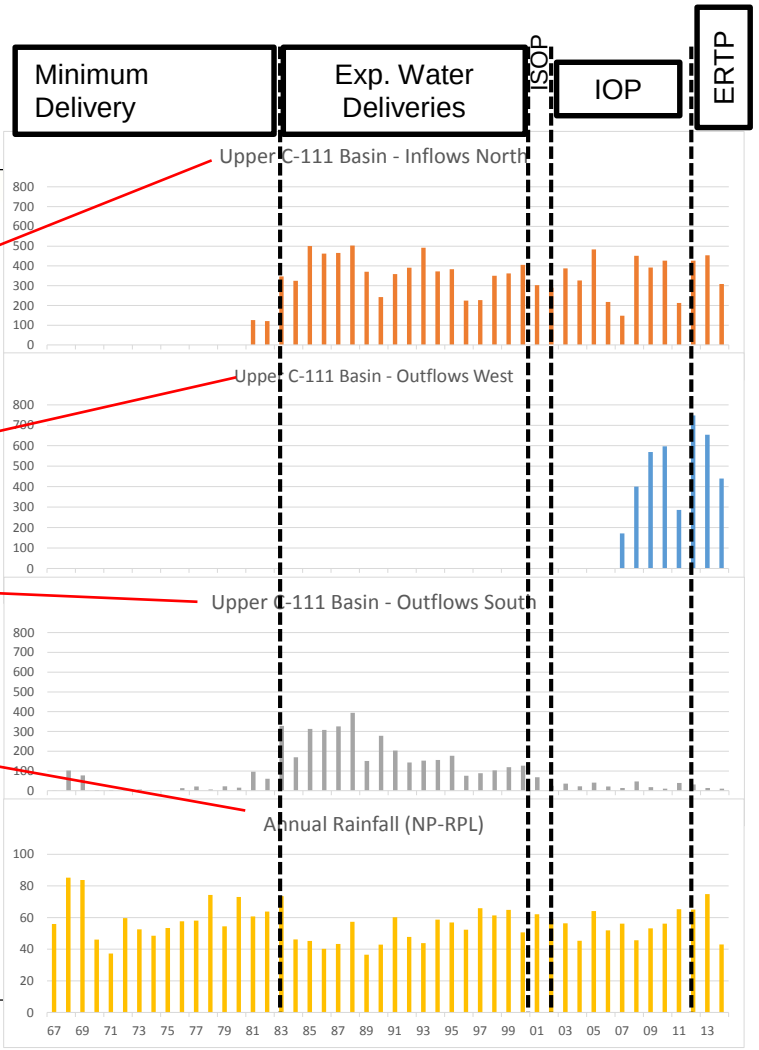
- The detention areas and their associated pump stations (S332s, S200s, S199s) move water from the L31N/C111 canals toward the west.
- These features are designed to leverage high seepage rates to convey water out of the facilities.
- Prior to the construction of these features, water was more frequently sent south (S176, S177, S178)

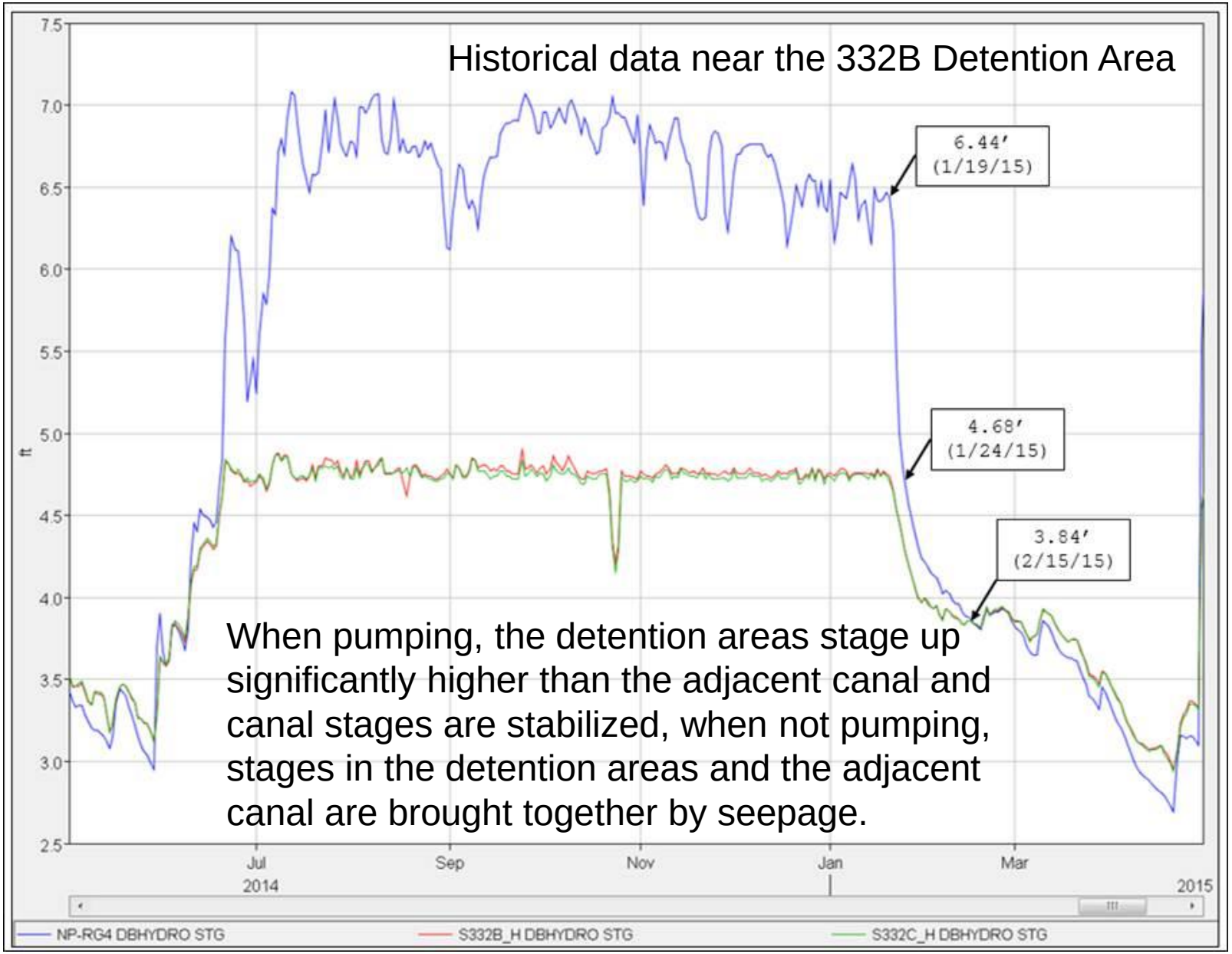


Historical Changes in Flow along L31N/C111 Canals

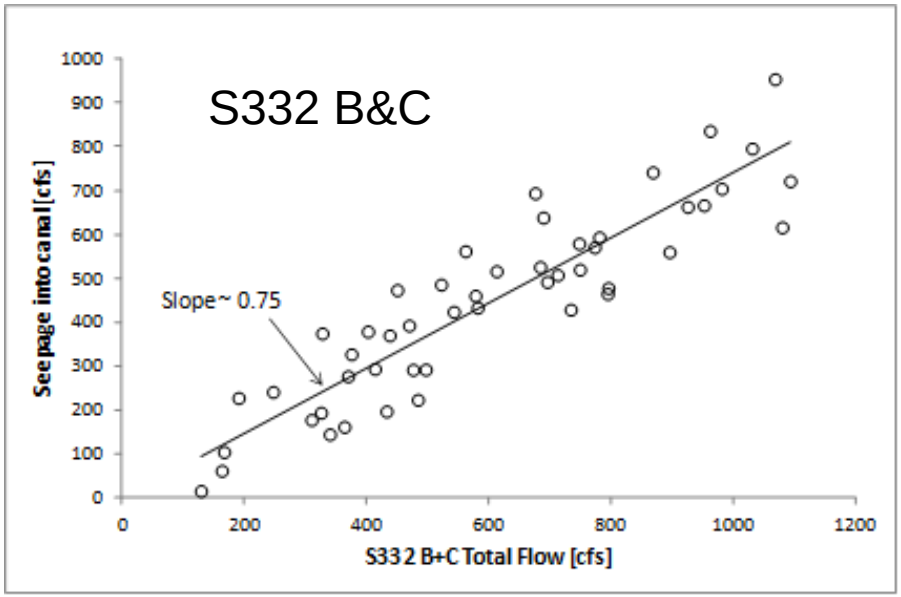
South Dade Conveyance System

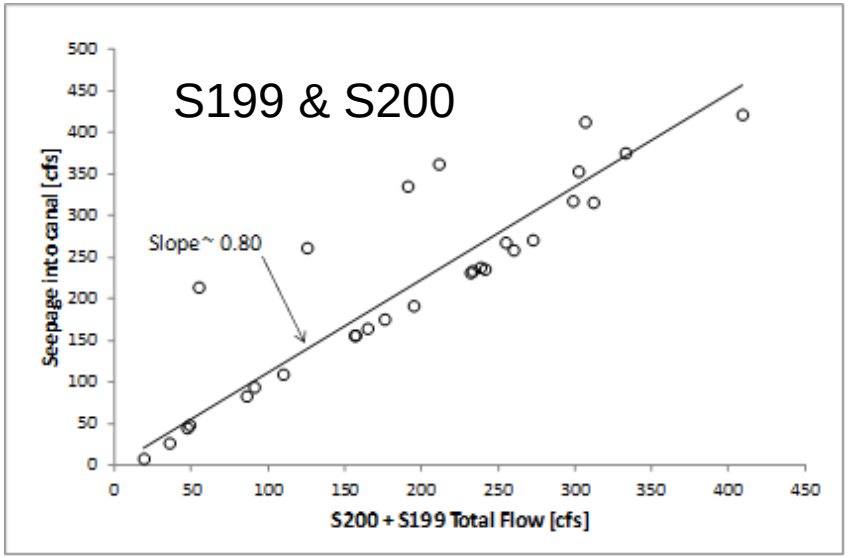




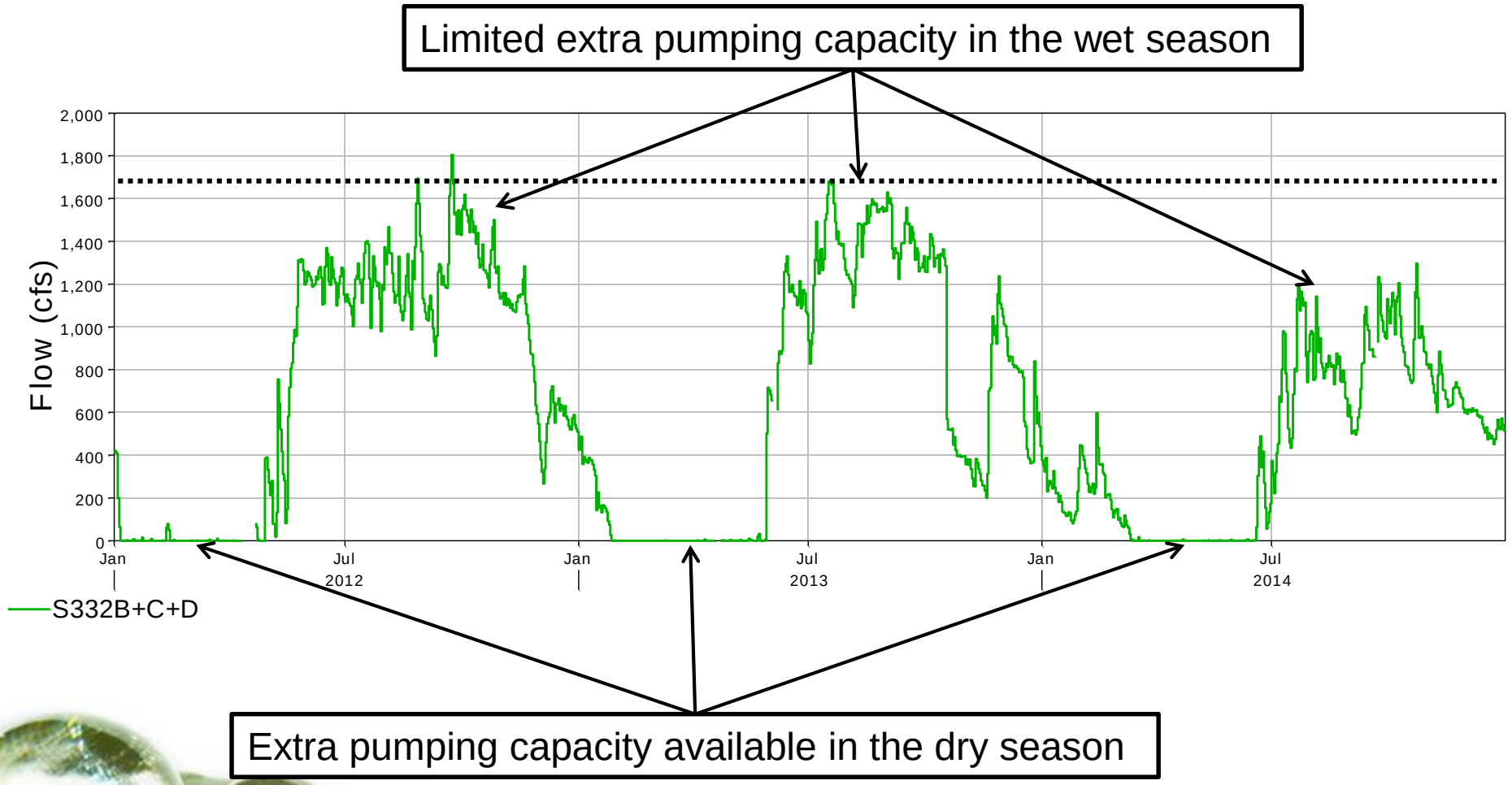

Historical data near the 332B Detention Area
6.44′
(1/19/15)
4.68′
(1/24/15)
3.84′
(2/15/15)
When pumping, the detention areas stage up significantly higher than the adjacent canal and canal stages are stabilized, when not pumping, stages in the detention areas and the adjacent canal are brought together by seepage.
ft
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
Jul
2014
Sep
Nov
Jan
Mar
2015
NP-RG4 DBHYDRO STG
S332B_H DBHYDRO STG
S332C_H DBHYDRO STG

Detention Area Pumping Largely Returns as Seepage





Capacity of Pump Stations



Moving Water West out of Detention Areas

- Preliminary modeling indicates that attempting to move water out of the detention areas toward the west via surface water discharges has limited effectiveness in more northern areas (e.g. 332B&C) and some feasibility near the headwater of Taylor Slough.
- For example, for every additional month that the S332D and S200 structures can be operated, these structures have the potential to send approximately 40,000 ac-ft of water toward Taylor Slough (not all gets into the Slough)

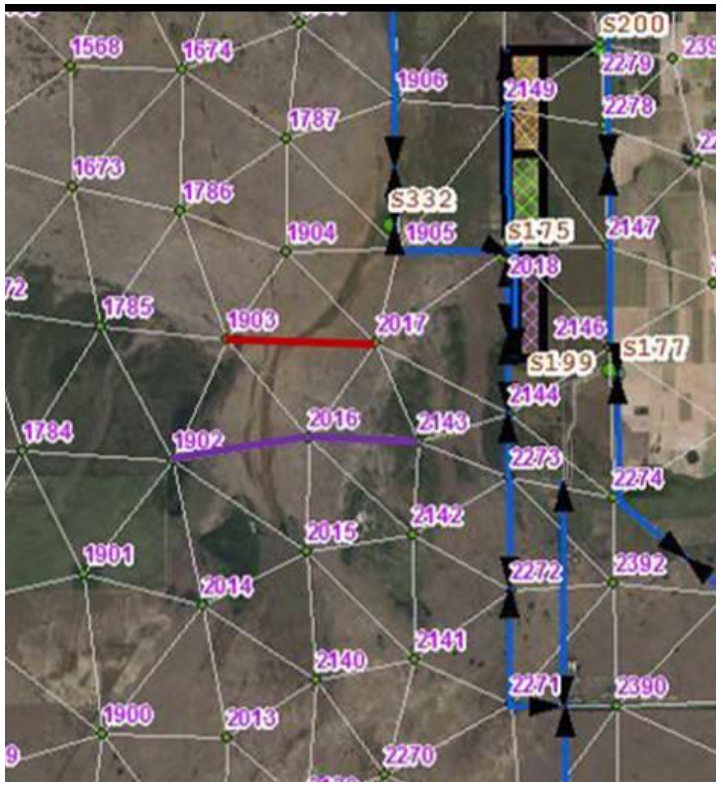
Modeled data comparing groundwater + levee seepage in kac-ft without/with 332 reservoir weirs (red circle shows small change with weirs)

	Seepage				
Levee Reach	ECBRW	S4.3	S4.4	S2R1C	S5
L-31N from G-211 to S-331	28.8	23.9	23.9	26.8	28.8
L-31N from S-331 to S-176	219.[illegible]	331.9	326.6	263.6	201.1
C-111 from S-176 to S-177	156.2	202.3	203.4	169.1	138.4
C-111 from S-177 to S-18C	42.8	59.3	59.7	72.9	38.9

Moving Water West out of Detention Areas (continued)

RW	ERTP Operations
4.9	4.3 + direct surface flow from 332D and FP Imp to L31W
4.10	4.3 + seepage wall

	RW	4.9	4.10
S332D1/2	105.1	120.5	121.3
SDNWE	7.6	0.0	14.3
S329	0.7	0.0	3.5
FP_OUT	-5.2	-14.4	-7.4
TSB_TRANSECT_1(OL)	14.9	28.0	20.5
TSB_TRANSECT_2(OL)	16.7	28.7	22.0



SDNWE - weir from D north reservoir to D south reservoir
S329 - weir from D south reservoir to frog pond area east of l31w
FP_OUT - open connection across l31w levee near s332
TSB_TRANSECT_1 - red line in map
TSB_TRANSECT_2 - purple line in map

Getting the Water Where We Want It

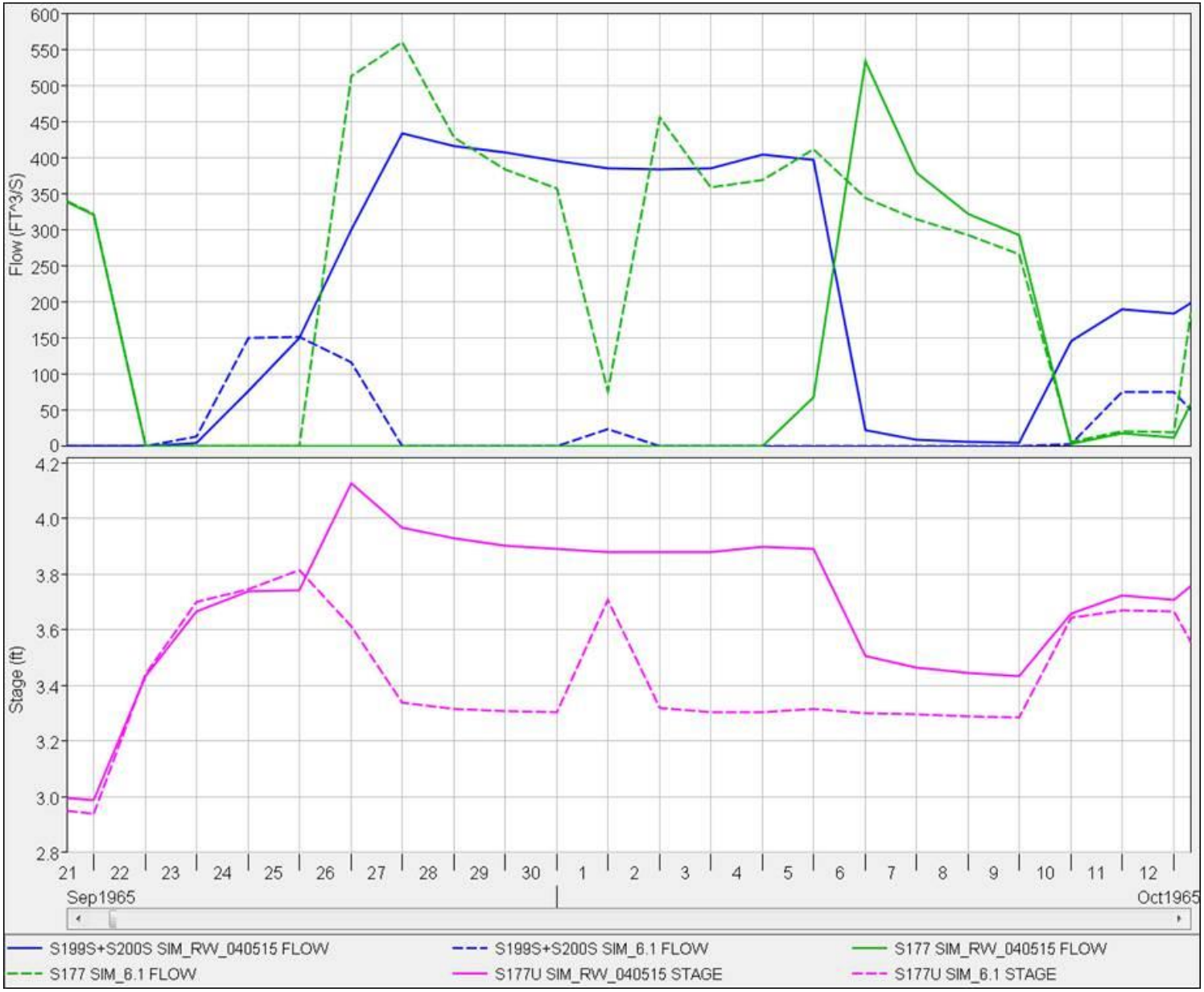
- Some dry season capacity available for L31N pump stations (S332 B,C,D); limited efficiency gains with surface water discharge
- Some potential to explore improved discharges via S332D or S200 toward Taylor Slough
- Limited dry season capacity for C111 pump stations (S200, S199)

- Some off-peak capacity to move water east toward Biscayne Bay via S338, S194, S196
- Capacity exists to more frequently utilize S176 & S177 (e.g. storm releases)
- Limited options to convey more water in the vicinity of S178
- Capacity available at S197, but releases are largely undesirable

Operational Refinement

- Typically when operational changes are discussed, persistent or seasonal changes in water level criteria are identified.
- While these type of operations can frequently balance multiple objectives, other operational changes can also be proposed that address a more targeted conditions (e.g. during rainfall events).

Example simulated post-storm drainage operations
(solid line without lowering S177, dashed line with lowering S177)



Sea Level Rise

Sea level rise effects are pertinent to the South Dade discussion in at least two ways:

- During storm events, higher tailwater at coastal structures could limit the discharge capacity (e.g. S197)
- Increased risk of saltwater intrusion into both developed and natural lands may require additional sources of water when canal stages fall during drier periods.